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I . FENT COOPERATION TREAT?

| From | the | INTERI | NAT | IONAL | BURE | ΑIJ |
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| | | | | | | |

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202

| Oate of mailing (day/month/year) 01 June 2001 (01.06.01) | ETATS-UNIS D'AMERIQUE in its capacity as elected Office |
|---|---|
| International application No. PCT/GB00/03491 | Applicant's or agent's file reference P23959A/JDB |
| International filing date (day/month/year) 12 September 2000 (12.09.00) | Priority date (day/month/year) 14 September 1999 (14.09.99) |
| Applicant | |
| VAN DER ENDE, Andre, Martin et al | |

| 1. | The designated Office is hereby notified of its election made: |
|----|---|
| | X in the demand filed with the International Preliminary Examining Authority on: |
| | 12 April 2001 (12.04.01) |
| | in a notice effecting later election filed with the International Bureau on: |
| | |
| | |
| 2. | The election X was |
| | was not |
| | made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b). |
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The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland

Authorized officer

Olivia TEFY

Telephone No.: (41-22) 338.83.38

Form PCT/IB/331 (July 1992)

Facsimile No.: (41-22) 740.14.35

GE 0003491



US

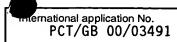
PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

| Applicant's or agent's file reference | FOR FURTHER see Notification of | of Transmittal of International Search Report |
|---|--|---|
| P23959A/JDB | ACTION (FORM PC 17/15A/2 | 220) as well as, where applicable, item 5 below. |
| International application No. | International filing date (day/month/year) | (Earliest) Priority Date (day/month/year) |
| PCT/GB 00/03491 | 12/09/2000 | 14/09/1999 |
| Applicant | | |
| | _ | |
| MACHINES (U.K.) LIMITED et | t al. | |
| This International Search Report has been according to Article 18. A copy is being tra | n prepared by this International Searching Auth Insmitted to the International Bureau. | nority and is transmitted to the applicant |
| This International Search Report consists It is also accompanied by | of a total of 5 sheets. a copy of each prior art document cited in this | report. |
| 1. Basis of the report | | |
| With regard to the language, the i language in which it was filed, unle | international search was carried out on the bas ess otherwise indicated under this item. | is of the international application in the |
| the international search w Authority (Rule 23.1(b)). | as carried out on the basis of a translation of th | ne international application furnished to this |
| b. With regard to any nucleotide and was carried out on the basis of the contained in the internation | e sequence listing : nal application in written form. | ternational application, the international search |
| | rnational application in computer readable forn this Authority in written form. | 1. |
| | this Authority in computer readble form. | |
| <u>-</u> | sequently furnished written sequence listing do | oes not go beyond the disclosure in the |
| | | identical to the written sequence listing has been |
| 2. Certain claims were four | nd unsearchable (See Box I). | |
| 3. Unity of invention is lact | king (see Box II). | |
| 4. With regard to the title , | | |
| the text is approved as su | bmitted by the applicant. | |
| X the text has been establish | hed by this Authority to read as follows: | |
| APPARATUS AND METHOD F | OR MEASURING DEPTH | |
| VERFAHREN UND VORRICH | TUNG ZUR TIEFENMESSUNG | |
| 5. With regard to the abstract, | • | |
| X the text is approved as sul | bmitted by the applicant. | |
| the text has been established | hed, according to Rule 38.2(b), by this Authority date of mailing of this international search rep | y as it appears in Box III. The applicant may, ort, submit comments to this Authority. |
| 6. The figure of the drawings to be publi | | 1 |
| X as suggested by the applic | cant. | None of the figures. |
| because the applicant faile | ed to suggest a figure. | |
| because this figure better | characterizes the invention. | |

INTERNATIONAL SEARCH REPORT



| Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sh et) |
|--|
| This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons: |
| Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely: |
| Claims Nos.: because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically: |
| 3. Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a). |
| Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet) |
| This International Searching Authority found multiple inventions in this international application, as follows: |
| see additional sheet |
| As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims. |
| 2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee. |
| 3. As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.: |
| 4. No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: |
| Remark n Pr test The additional search fees were accompanied by the applicant's protest. X No protest accompanied the payment of additional search fees. |

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-14

Communication system

2. Claims: 15-35

Downhole depth measurement system



A. CLASSIFICATION OF SUBJECT MATTER IPC 7 E21B47/12 E21B47/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols) $IPC \ 7 \qquad E21B$

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

| C. DOCUM | ENTS CONSIDERED TO BE RELEVANT | |
|------------|--|---------------------------|
| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
| X | US 4 001 774 A (DAWSON ET AL.) 4 January 1977 (1977-01-04) column 3, line 30 - line 64 column 4, line 19 - line 34 | 1-13 |
| Y | | 14,18, 20,23, 29,35 |
| Y | US 4 814 548 A (TRAVERSINO ET AL.) 21 March 1989 (1989-03-21) column 1, line 44 - line 46 | 14 |
| Α | US 3 209 323 A (GROSSMAN) 28 September 1965 (1965-09-28) column 5, line 18 - line 37 | 1 |
| | | |

| Further documents are listed in the continuation of box C. | Y Patent family members are listed in annex. |
|---|---|
| Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed | "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family |
| Date of the actual completion of the international search | Date of mailing of the international search report |
| 28 February 2001 | 0 6. 03. 2001 |
| Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016 | Authorized officer Rampelmann, K |



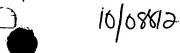
| | | 101/48 00/03491 |
|------------|--|--|
| | ation) DOCUMENTS CONSIDERED TO BE RELEVANT | F2 |
| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
| X | GB 936 461 A (TROSZT) 11 September 1963 (1963-09-11) | 15-17, 19,22, 24,25, 27,28, 30,32-34 |
| | page 3, line 27 - line 39 page 3, line 79 - line 91 page 4, line 49 - line 57 claim 1 | |
| Y | | 14,18, 20,23, 29,35 |
| X | US 3 267 365 A (BAKER) 16 August 1966 (1966-08-16) | 15-17, 19,22, 24,25, 27,28, 30,32,34 |
| | column 1, line 29 - line 35 column 4, line 34 -column 5, line 39 | |
| X | US 3 185 997 A (CARLTON ET AL.) 25 May 1965 (1965-05-25) | 15,16, 21,22, 26-28,34 |
| | column 1, line 40 - line 42 column 2, line 32 - line 43 column 2, line 63 -column 3, line 42 | |
| X | US 4 044 470 A (DUFRENE) 30 August 1977 (1977-08-30) column 4, line 35 - line 68 | 22,24 |
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INTERMATIONAL SEARCH REPORT

Information on patent family members



| Patent document cited in search report | : | Publication date | Patent family member(s) | Publication date |
|---|---|---------------------|-------------------------|------------------|
| US 4001774 | Α | 04-01-1977 | NONE | |
| US 4814548 | Α | 21-03-1989 | NONE | |
| US 3209323 | Α | 28-09-1965 | NONE | |
| GB 936461 | Α | | NONE | |
| US 3267365 | Α | 16-08-1966 | NONE | |
| US 3185997 | Α | 25-05-1965 | NONE | |
| US 4044470 | Α | 30-08-1977 | NONE | |





INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/03491

| | l. | Bas | sis of the report | | | | | | | |
|---|-----|------------|--|---|-------------------------|----------------------|---|--|--|--|
| | .1. | the and | With regard to the elements of the international application (Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)). Description, pages: | | | | | | | |
| | | 1-3 | 7 | as originally filed | | | | | | |
| | | Cla | ims, No.: | | | | | | | |
| | | 1-3 | 5 | as received on | 11/10/2001 | with letter of | 11/10/2001 | | | |
|) | | Dra | wings, sheets: | | | | | | | |
| | | 1/5 | -5/5 | as originally filed | | | | | | |
| | | | , | | | | | | | |
| | 2. | | - | guage, all the elements r international application | | | ed to this Authority in the nder this item. | | | |
| | | The | ese el ements wer e | available or fumished to | this Authority in the f | ollowing language | : , which is: | | | |
| | | | the language of a | translation furnished for | the purposes of the i | ntemational searc | h (under Rule 23.1(b)). | | | |
| | | | the language of p | ublication of the Internation | onal application (und | er Rule 48.3(b)). | | | | |
| | | | the language of a 55.2 and/or 55.3). | | the purposes of inter | national prelimina | ry examination (under Rule | | | |
| | 3. | | • | cleotide and/or amino a ry examination was carri | | | • • | | | |
| | | | contained in the in | nternational application in | written form. | | | | | |
| | | | filed together with | the international applica | tion in computer read | dable form. | | | | |
| | | | furnished subseq | uently to this Authority in | written form. | | | | | |
| | | | furnished subseq | uently to this Authority in | computer readable f | orm. | | | | |
| | | | | at the subsequently furnis application as filed has be | | e listing does not | go beyond the disclosure in | | | |
| | | | The statement that listing has been for | • | ed in computer reada | ble form is identica | al to the written sequence | | | |
| | 4. | The | e amendments hav | e resulted in the cancella | tion of: | | | | | |
| | | | the description, | pages: | | | | | | |
| | | | the claims, | Nos.: | | | | | | |

INTERNATIONAL PRELIMINARY EXAMINATION REPORT



International application No. PCT/GB00/03491

| | | | the drawings, | sheets: | | | | | | |
|--------------|-----|-------------|--|-------------|------------------|---|--|--|--|--|
| | 5. | | | | | ome of) the amendments had not been made, since they have been as filed (Rule 70.2(c)): | | | | |
| | | | (Any replacement sh report.) | eet contai | ning such | amendments must be referred to under item 1 and annexed to this | | | | |
| | 6. | Add | litional observations, i | f necessar | y : | | | | | |
| | IV. | . Lac | ek of unity of invention | on | | | | | | |
| | 1. | In re | esponse to the invitation | on to restr | ict or pay | additional fees the applicant has: | | | | |
| | | | restricted the claims. | | | | | | | |
| | | | paid additional fees. | | | · | | | | |
| | | | paid additional fees u | ınder prote | est. | | | | | |
| | | | neither restricted nor | paid addi | tional fees | 5. | | | | |
| | 2. | ⊠ | This Authority found that the requirement of unity of invention is not complied and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees. | | | | | | | |
| | 3. | This | s Authority considers t | hat the rec | quirement | of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is | | | | |
| | | | complied with. | | | | | | | |
| , | | | not complied with for | the follow | ing reaso | ns: | | | | |
| | 4. | | sequently, the following mination in establishing | | | national application were the subject of international preliminary | | | | |
| | | \boxtimes | all parts. | | | | | | | |
| | | | the parts relating to o | daims Nos | i | | | | | |
| | ٧. | | soned statement un | | | ith regard to novelty, inventive step or industrial applicability; | | | | |
| | 1. | Stat | ement | | - | | | | | |
| | | Nov | relty (N) | Yes: No: | | 1-9, 14, 26, 33 10-13, 15-25, 27-32, 34-35 | | | | |
| | | inve | entive step (IS) | Yes: No: | Claims Claims | 1-35 | | | | |



INTERNATIONAL PRELIMINARY EXAMINATION REPORT



International application No. PCT/GB00/03491

Industrial applicability (IA)

Yes:

Claims 1-35

No: Claims

2. Citations and explanations see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted: see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made: see separate sheet



INTERNATIONAL PRELIMINARY InterEXAMINATION REPORT - SEPARATE SHEET

International application No. PCT/GB00/03491

Reference is made to the following documents:

D1: US-A-4 001 774 D2: US-A-3 267 365 D3: US-A-3 185 997 D4: US-A-3 209 323

Re Item IV

Lack of unity of invention

- IV-1 Even though none of the independent claims seem to meet the requirements of Article 33(2) or (3) PCT, this International Examining Authority confirms the founding of the International Searching Authority concerning the presence of two groups of inventions in the present application. Said two groups of inventions can be identified as follows:
 - 1. Claims 1-14: Communication system
 - 2. Claims 15-35: Downhole depth measurement system

The "special technical feature" (in the meaning of Rule 13.2 PCT) of the first group of inventions is that the wireline serves as a telemetry link between communications equipment located downhole and communications equipment located topsides. The problem solved by said feature is to provide a way of communication between said mutually remote locations.

The "special technical feature" (in the meaning of Rule 13.2 PCT) of the second group of inventions is to provide depth information for equipment travelling up or down a well by referencing to known locations in said well. The problem solved is therefore how to know the actual travelled distance of a piece of equipment that has been placed inside a well.

The "special technical feature" of the two groups of inventions are therefore different and solve different problems so that no technical relationships can be seen among them. According to Rule 13.2 PCT, the application does therefore not meet the requirement of Rule 13.1 PCT.



INTERNATIONAL PRELIMINARY

International application No. PCT/GB00/03491

EXAMINATION REPORT - SEPARATE SHEET

Re Item V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

V-1 D1, which is considered the closest prior art, discloses the subject-matter of claim 1 as follows (the references in parentheses applying to this document):

> A communication system for use in a wellbore (col. 1, l. 9-12), the system comprising a downhole tool (21), the downhole tool (21) comprising a transmitter (col. 3, I. 56), the downhole tool (21) being coupled to a wireline (40), wherein the downhole tool (21) and wireline (40) are adapted to be inserted into the wellbore (17), and a receiver (28) located remotely from the transmitter (see fig. 1), wherein the wireline (40) is capable of acting as an antenna for the transmitter (col. 3, I. 57-58).

The apparatus according to claim 1, therefore differs with respect to D1 in that the wireline is also capable of running the downhole tool into the wellbore.

The apparatus according to claim 1 is therefore new and the claim meets the novelty requirements of Article 33(2) PCT.

V-2 The distinguishing feature of claim 1 is thus related the problem of how to more efficiently deploy a device or downhole tool into a wellbore.

> In particular, in view of D4, fig. 1, said distinguishing feature of claim 1 does not involve an inventive step in the meaning of Article 33(3) PCT. It is considered obvious that the skilled man would adapt the teaching from D4 into D1 in order to solve the problem.

V-3 Furthermore, D1 discloses the subject-matter of the following claims:

Claim 2: see col. 4, I. 23-24

Claim 3: see fig. 1, item 21

Claim 4: see fig. 1, item 40



INTERNATIONAL PRELIMINARY **EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/03491

Claim 5: see col. 3, I. 43-46 Claim 6: see fig. 1, item 28 Claim 7: see col. 3, I. 33-39 Claim 8: see col. 3, 1, 58-59

Claim 9: see col. 4, I. 23-24

The subject-matter of said claims does therefore not involve an inventive step (Article 33(3) PCT).

V-4 With respect to independent claim 10, and in addition to what has already been said under section V-1, D1 in fig. 1 furthermore discloses that a wireline 40 including its ends with a transmitter 21 attached to the one of said ends, has in one way or another been payed into the borehole 17. See also col. 4, 1. 27-34.

> Said claim does therefore not meet the novelty requirements of Article 33(2) PCT in that the claim is not new over D1.

- V-5 Also independent claim 11 as well as dependent claims 12 and 13 do not seem to contain novel subject-matter over D1 (see col. 4, I. 19-26). Said claims do therefore not meet the novelty requirements of Article 33(2) PCT).
- V-6 The subject-matter of dependent claim 14 is consider an obvious design alternative for the skilled man when solving the problem of insulation material selection. Said claim does therefore not involve an inventive step (Article 33(3) PCT).
- V-7 D2 discloses the subject-matter of claim 15 as follows (the references in parentheses applying to this document):

A distance measurement apparatus (fig. 1) for measuring the distance travelled by a wireline (17), the apparatus (fig. 1) comprising at least two sensors (fig. 6, item 64, 65) coupled to the wireline (17) wherein the sensors (64, 65) are capable of sensing known locations (15) in a wellbore (11).

INTERNATIONAL PREZIMINARY International application No. PCT/GB00/03491 EXAMINATION REPORT - SEPARATE SHEET

The subject-matter of claim 15 is therefore not new contrary to the provisions of Article 33(2) PCT.

The applicants attention is drawn to the fact that even if D2 did not disclose a plurality of sensors, claim 15 would not be considered as involving an inventive step in the meaning of Article 33(3) PCT by just limiting the possible number of sensors to the system.

- V-8 Furthermore, D2 discloses the subject-matter of claim 16 as any line can be seen as a slick line. Claim 16 is therefore not new (Article 33(2) PCT). See also section VIII-3.
- V-9 Furthermore, D2 discloses the subject-matter of the following claims:

Claim 17: see fig. 1, item 56

Claim 18: see fig. 1, item 17

Claim 19: see col. 3, I. 48-52

Claim 20: see col. 2, I. 47

The subject-matter of said claims is therefore not new (Article 33(2) PCT).

V-10 Also the subject-matter of independent claim 21 and 22 is disclosed by D2. See in particular fig. 1 of D2. Refer also to sections V-5 above.

The subject-matter of claims 21 and 22 is therefore not new contrary to the provisions of Article 33(2) PCT.

- V-11 Furthermore, D2 discloses the subject-matter of the following claims:
 - Claim 23: see fig. 1, item 17, where the cable 17 can be said to act as an antenna, i.e. the medium upon which the signal is transferred to the recorder 56.
 - Claim 24: see fig. 1, the socket is part of the arrangement referred to as 21.



INTERNATIONAL PROMINARY Internation EXAMINATION REPORT - SEPARATE SHEET

International application No. PCT/GB00/03491

Claim 25: as the signal is clearly going from the sensor 50 to cable 17, the socket must include means to expedite the signal through the socket.

The subject-matter of said claims is therefore not new (Article 33(2) PCT).

- V-12 Claim 26 does not involve an inventive step (Article 33(3) PCT). See D3, fig. 3, item 30.
- V-13 Independent method claim 27 relates effectively to the same subject-matter as independent claim 21 and does therefore also not meets the requirements of Article 33(2) PCT.
- V-14 As far as claim 28 can be understood, said claim relates effectively to the same subject-matter as independent claim 21 and does therefore also not meets the requirements of Article 33(2) PCT. See also section VIII-2.
- V-15 What has been said about claim 23 applies also to claim 29. The subject-matter of said claims is therefore not new (Article 33(2) PCT).
- V-16 Furthermore, at least D2 discloses the subject-matter of the following claims:

Claim 30: see col. 4, l. 48-52

Claim 31: see col 5, I. 30-32

Claim 32: see fig. 1, item 56

Claim 34: see col 4, I. 40-52

Claim 35: see: col. 2, l. 47

The subject-matter of said claims is therefore not new (Article 33(2) PCT).

V-17 With respect to claim 33, it is considered as normal practice, in the industry, to select between the features of having one-way or two-way communication between two stations, when designing a telemetry link. said claim does therefore not involve an inventive step (Article 33(3) PCT).



INTERNATIONAL PR **EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/03491

Re Item VII

C rtain defects in the international application

- VII-1 The independent claims are not in the two-part form in accordance with Rule 6.3(b) PCT, which in the present case would be appropriate, with those features known in combination from D1-D2 being placed, where appropriate, in the preamble (Rule 6.3(b)(i) PCT) and with the remaining features being included in the characterising part (Rule 6.3(b)(ii) PCT).
- The features of the claims are not provided with reference signs placed in VII-2 parentheses (Rule 6.2(b) PCT).
- Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background VII-3 art disclosed in D1-D4 is not mentioned in the description, nor are these documents identified therein.

Re Item VIII

Certain observations on the international application

- To satisfy the conciseness requirement or Article 6 PCT, the present set of VIII-1 claims should include only the minimum necessary number of independent claims in any one category. Said requirement is not satisfied by any of the independent claims, as in the present case, it is considered appropriate to use only one independent claim in any one category.
- VIII-2 Claim 28 in not clear (Article 6 PCT) in that it can not be determined if the "configuration of the downhole tool or tool string", as specified in the claim, refers to the location of the tool in the borehole or if it refers to the composition of the casing as such, alternatively to the tool string being run inside the casing.
- VIII-3 At least claims 2, 13 and 16 do not meet the requirements of Article 6 PCT in that the matter for which protection is sought is not clearly defined as the term "slickline" does not univocally imply any specific structural feature. The claim attempts therefore to define the subject-matter in terms of the result to

EXAMINATION REPORT - SEPARATE SHEET

International application No. PCT/GB00/03491

be achieved which merely amounts to a statement of the underlying probl_m. The technical features necessary for achieving this result should be added.

34 MAID

CLAIMS:-

<u>1</u> 2

- A communication system for use in a wellbore,
- 4 the system comprising a downhole tool, the downhole
- 5 tool comprising a transmitter, the downhole tool
- 6 being coupled to a wireline, wherein the downhole
- 7 tool and wireline are adapted to be inserted into
- 8 the wellbore, and a receiver located remotely from
- 9 the transmitter, wherein the wireline is capable of
- 10 running the downhole tool into the wellbore and is.
- 11 also capable of acting as an antenna for the
- 12 transmitter.

13

- 14 2. An apparatus according to claim 1, wherein the
- 15 wireline is a slickline.

16

- 17 3. An apparatus according to either of claims 1 or
- 18 2, wherein the transmitter is further associated
- 19 with, provided on, or an integral part of a tool
- 20 string.

2<u>1</u>

- 22 4. An apparatus according to claim 3, wherein the
- 23 downhole tool or tool string is suspended by the
- 24 wireline.

25

- 26 5. An apparatus according to either of claims 3 or
- 27 4, wherein the transmitter transmits data collected
- or generated by the downhole tool or the like to the
- 29 receiver.



| 1 | 6. | An | annaratue | 2552244 | _ | | | • |
|---|----|----|-----------|-----------|----|-----|-----------|-------|
| | | | apparetus | according | £0 | any | preceding | claim |

- Wherein the receiver is located at, or near, the
- 3 surface of the wellbore.

4

- 5 7. An apparatus according to any preceding claim,
- 6 wherein the distance travelled by the downhole tool,
- 7 the status of the downhole tool or other parameters
- 8 of the downhole tool, can be transmitted to the
- 9 receiver.

10

- 11 8. Apparatus according to any preceding claim,
- wherein the wireline is electrically insulated.

13

- 14 9. Apparatus according to any preceding claim,
- 15 wherein the wireline is sheathed to facilitate
- 16 electrical insulation.

17

- 18 10. A method of communication in a wellbore,
- 19 comprising providing a downhole tool comprising a
- 20 transmitter, coupling the downhole tool to a
- 21 wireline, paying an end of the wireline and the
- 22 downhole tool into the wellbore, and providing a
- 23 receiver located remotely from the transmitter, such
- 24 that the wireline acts as an antenna for the
- 25 transmitter.

26

- 27 ll. A slickline for use in a wellbore, wherein the
- 28 slickline is provided with an insulating coating.

- 30 12. A slickline according to claim 11, wherein the
- 31 insulating coating is an outer coating of the
- 32 slickline.

1

- 2 13. A slickline according to either of claims 11 or
- 3 12, wherein the coating comprises a stress/impact
- 4 sensitive material.

5

- 6 14. A slickline according to any of claims 11 to
- 7 13, wherein the insulating coating comprises at
- 8 least one enamel material.

9

- 10 15. A distance measurement apparatus for measuring
- Il the distance travelled by a wireline, the apparatus
- 12 comprising at least two sensors coupled to the
- 13 wireline wherein the sensors are capable of sensing
- 14 known locations in a wellbore.

15

- 16 16. Apparatus according to claim 15, wherein the
- 17 wireline is a slickline.

18

- 19 17. Apparatus according to either of claims 15 or
- 20 16, wherein the apparatus includes transmission
- 21 means for transmitting data collected by the at
- least two sensors to a receiver located remotely
- 23 from the apparatus.

24

- 25 18. Apparatus according to claim 17, wherein the
- 26 wireline is capable of acting as an antenna for the
- 27 transmission means.

- 29 19. Apparatus according to either of claims 17 or
- 30 18, wherein the sensors are coupled at or near a
- 31 downhole tool whereby the distance travelled by the

41 tool, and the location of the tool within the

wellbore, can be calculated.

2 3

1

- 4 Apparatus according to any of claims 17 to 19,
- wherein the wireline is electrically insulated. 5

6

- A method of measuring the distance travelled by 7
- a wireline, the method comprising the steps of 8
- coupling at least two sensors to the wireline, the 9
- at least two sensors being capable of sensing known 10
- locations in a wellbore; running the wireline into 11
- the wellbore; calculating the depth of the at least 12
- two sensors; generating a signal when each of the at 13
- least two sensors pass said known locations; using 14
- the signals to calculate a depth correction factor; 15
- and correcting the calculated depth using the depth 16
- 17 correction factor.

18

- A downhole tool comprising coupling means to 19
- allow the tool to be attached to a wireline, at 20
- least two sensors capable of detecting known 21
- locations in a wellbore and generating a signal 22
- indicative thereof, and a transmission means capable 23
- of transmitting the signals. 24

25

- 23. A downhole tool according to claim 22, wherein 26
- 27 the wireline acts as an antenna for the transmission
- 28 means.

- 30 A downhole tool according to either of claims
- 22 or 23, wherein the coupling means comprises a 31
- 32 rope-socket.

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- 2 25. A downhole tool according to claim 24, wherein
- 3 the rope-socket is provided with signal coupling
- 4 means to couple the signals generated by the
- 5 transmission means to the wireline.

6

- 7 26. A downhole tool according to any of claims 20
- 8 to 23, wherein the downhole tool is powered by a DC
- 9 power supply.

10

- 27. A method of tracking a member in a wellbore,
- 12 the method comprising providing at least two sensors
- on the member, inserting the member and said sensors
- 14 into the wellbore, obtaining information indicating
- 15 the position of the sensors in the wellbore, and
- 16 determining the distance travelled by said member
- 17 from said sensor information.

18

- 19 28. Apparatus for indicating the configuration of a
- 20 downhole tool or tool string, the apparatus
- 21 comprising at least two sensors capable of sensing a
- 22 change in the configuration of the downhole tool or
- 23 tool string and generating a signal indicative
- 24 thereof, and a transmission means electrically
- 25 coupled to the at least two sensors for transmitting
- 26 the signals to a receiver.

27

- 28 29. Apparatus according to claim 28, wherein the
- 29 downhole tool is preferably suspended in a borehole
- 30 using a wireline, and the wireline is capable of
- 31 acting as an antenna for the transmission means.

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- 1 30. Apparatus according to either of claims 28 or
- 2 29, wherein the transmitter facilitates the
- 3 transmission of data collected by the sensors to the
- 4 receiver.

5

- 6 31. Apparatus according to any of claims 28 to 30,
- 7 wherein the transmission means comprises a
- 8 transmitter.

9

- 10 32. Apparatus according to any of claims 28 to 31,
- 11 wherein the receiver is located at, or near, the
- 12 surface of the borehole.

13

- 14 33. Apparatus according to any of claims 26 to 30,
- wherein the apparatus is arranged whereby it can
- 16 facilitate two-way communication between the
- 17 downhole tool and the receiver.

18

- 19 34. Apparatus according to any of claims 28 to 32,
- 20 wherein the sensors comprise electric or magnetic
- 21 sensors which are coupled to the downhole tool
- 22 wherein a discontinuity of the respective electric
- 23 or magnetic connection triggers a signal by each
- 24 sensor.

- 26 35. Apparatus according to any of claims 29 to 34,
- 27 wherein the wireline is electrically insulated.

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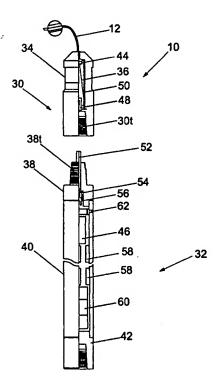
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[Continued on next page]

(54) Title: APPARATUS AND METHODS RELATING TO DOWNHOLE OPERATIONS



(57) Abstract: A communication system for use in a wellbore, a downhole tool, and a method includes a transmitter coupled to a wireline, and a receiver located remotely from the transmitter. The wireline is capable of acting as an antenna for the transmitter, The wireline is a slickline, and the transmitter may be associated with, provided on, or an integral part of a downhole tool or tool string. The transmitter typically transmits data collected or generated by the downhole tool or the like to the receiver, which is preferably located at, or near, the surface of the wellbore. The wireline is typically provided with an insulating coating. Also, a distance measurement apparatus and a method for measuring the distance travelled by a wireline includes at least one sensor coupled to the wireline, and the sensor is capable of sensing known locations in a wellbore.

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"Apparatus and Methods Relating to Downhole 1 Operations" 2 3 The present invention relates to apparatus and 4 methods relating to downhole operations, and 5 particularly, but not exclusively, to wireline 6 7 operations. 8 Wireline is a term commonly used for the operation of 9 deploying and/or retrieving tools or the like using a 10 wire, the wire being one of several different types 11 of construction. For example, slicklines are wires 12 which comprise a single strand steel or alloy piano-13 type wire which currently have a diameter of around 14 0.092 inches to 0.125 inches (approximately 2.34mm to 15 3.17mm) in use, with the possibility of increasing 16 this to 0.25 inches (approximately 6.25mm) in the 17 future. 18 19

Wirelines may also be of a braided construction which 1 can also carry single or multiple electrical 2 conductor wires through its core and is typically of 3 a diameter in the order of 3/16 of an inch 4 (approximately 4.76mm) or above. Slick tubing, more 5 commonly known as coiled tubing, is in the form of a 6 continuous hollow-cored steel or alloy tubing which 7 is usually of a diameter greater than the preceding 8 types of wireline. 9 10 Wirelines are conventionally used to insert and/or 11 retrieve downhole tools from a wellbore or the like. 12 The downhole tools are typically deployed to perform 13 various downhole functions and operations such as the 14 deployment and setting of plugs in order to isolate a 15 section of the wellbore. It is advantageous and 16 often essential to know the distance of travel of the 17 wireline so that the location of the tool within the 18 wellbore is known. 19 20 Wirelines are conventionally stored on a winching 21 unit typically located at the surface in the 22 proximity of the top of a borehole. It should be 23 noted that "surface" in this context is to be 24 understood as being either atmospheric above ground 25 or sea level, or aquatic above the seabed. Although 26 the methods and apparatus employed in wireline 27 operations vary in detail, the wireline is commonly 28 introduced into the wellbore (the wellbore 29 conventionally being cased, as is known) via a series 30 of sheaves or guide rollers. The sheaves or guide

rollers facilitate, in the first instance, a 1 substantially vertical orientation of the wireline. 2 The wireline passes through a substantially 3 vertically-orientated superstructure tube having an 4 internal open-ended bore, the tube being positioned 5 on top of a wellhead. Thus, any downhole tool can be 6 introduced into the wellbore. 7 8 The wireline is coupled at its distal (downhole) end 9 to the downhole tool, typically via a part of the 10 tool known as a rope-socket. The rope-socket is 11 12 conventionally used to provide a mechanical connection between the wireline and the downhole tool 13 (or a string of downhole tools known as a tool 14 15 string). 16 The conventional method of measuring the downhole 17 tool depth is to run the wireline against a measuring 18 wheel which is a pulley wheel of known diameter. 19 should be noted that use of "depth" in this context 20 is to be understood as being the trajectory length of 21 the downhole tool, which may be different from 22 conventional depth if the wellbore is deviated, for 23 example. In order to calculate the distance of 24 travel of the wireline, a number of variable factors 25 must be known. It is a prerequisite that the 26 rotational direction of the pulley wheel, the number 27 of revolutions thereof, the diameter of the pulley 28 wheel and, depending upon the type of pulley wheel 29 (that is, whether a point-type contact or arc for 30 example), the diameter of the wireline, must all be 31

known before the distance of travel of the wireline 1 within the wellbore can be calculated. 2 3 However, with this conventional method for 4 calculating the distance of travel of the wireline, a 5 number of factors can render the calculation 6 inaccurate. The occurrence of wheel slippage, the 7 stretch of the wireline (due to the weight of the 8 wireline itself, and/or the weight of the tool string 9 which is attached thereto), the effect of friction 10 and the well-contained fluid buoyancy all contribute 11 to decrease the accuracy of the tool depth 12 13 measurement. 14 In order to improve the accuracy of this conventional 15 depth measurement, it is known to combine the 16 measured tensile load, the known stretch co-efficient 17 of the wireline, and the conventionally measured tool 18 depth as described above, to recalculate the tool 19 depth measurement on a continuous basis (ie in real 20 time) using a processing means, such as a computer or 21 the like. 22 23 However, the accuracy of the aforementioned depth 24 measurement correction method relies on an 25 experimentally determined constant (ie the stretch 26 co-efficient of the wireline) and the surface 27 measurements on the wireline. The resulting 28 correction does not include the significant combined 29

effect that well fluid temperature, tool buoyancy and

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well geometry have on the accuracy of the depth 1 correction. 2 3 According to a first aspect of the present invention 4 there is provided distance measurement apparatus for 5 measuring the distance travelled by a wireline, the 6 apparatus comprising at least one sensor coupled to 7 the wireline wherein the sensor is capable of sensing 8 known locations in a wellbore. 9 10 The wireline is typically a slickline. 11 12 According to a second aspect of the present invention 13 there is provided a method of measuring the distance 14 travelled by a wireline, the method comprising the 15 16 steps of coupling at least one sensor to the wireline, the at least one sensor being capable of 17 sensing known locations in a wellbore; running the 18 wireline into the wellbore; calculating the depth of 19 the at least one sensor using any conventional means; 20 generating a signal when the at least one sensor 21 passes said known locations; using the signal to 22 calculate a depth correction factor; and correcting 23 the calculated depth using the depth correction 24 factor. 25 26 Preferably, the apparatus includes transmission means 27 for transmitting data collected by the at least one 28 sensor to a receiver located remotely from the 29 apparatus. Preferably, the wireline is capable of 30 acting as an antenna for the transmission means. 31

1 The sensor may be coupled to the wireline at any 2 point thereon, or may form an integral part thereof. 3 The sensor is preferably coupled at or near a 4 downhole tool whereby the distance travelled by the 5 tool (and thus its location within the wellbore) can 6 be calculated. Alternatively, the sensor may form 7 part of a downhole tool or the like. 8 9 The sensor typically comprises a magnetic field 10 sensor, and preferably an array of magnetic field 11 The array of magnetic field sensors are 12 sensors. typically provided on a common horizontal plane. 13 Alternatively, the sensor may comprise a radio 14 frequency (RF) sensor, and preferably an array 15 thereof. Where an RF sensor is used, the wellbore is 16 typically provided with RF tags at known locations. 17 18 The wireline is preferably electrically insulated. 19 The wireline may be sheathed to facilitate electrical 20 insulation. Alternatively, the wireline may be 21 passed through a stuffing box or the like to 22 facilitate electrical insulation and/or isolation. 23 24 According to a third aspect of the present invention 25 there is provided a downhole tool comprising coupling 26 means to allow the tool to be attached to a wireline, 27 at least one sensor capable of detecting known 28 locations in a wellbore and generating a signal 29 indicative thereof, and a transmission means capable 30

of transmitting the signal.

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1 There is also provided a method of tracking a member 2 in a wellbore, the method comprising providing a 3 sensor on the member, inserting the member and sensor into the wellbore, obtaining information indicating 5 the position of the sensor in the wellbore, and 6 determining the distance travelled by said member 7 from said sensor information. 8 9 The wireline is preferably used as an antenna for the 10 11 transmission means. 12 The coupling means typically comprises a rope-socket. 13 The rope-socket is preferably provided with signal 14 coupling means to couple the signal generated by the 15 16 transmission means to the wireline. 17 The sensor typically comprises a magnetic field 18 sensor, and preferably an array of magnetic field 19 sensors. The array of magnetic field sensors are 20 typically provided on a common horizontal plane. 21 Alternatively, the sensor may comprise a radio 22 frequency (RF) sensor, and preferably an array 23 thereof. The array of RF sensors are typically 24 provided on a common horizontal plane. 25 26 The downhole tool is preferably powered by a DC power 27 supply, and most preferably a local DC power supply. 28 The DC power supply typically comprises at least one 29 battery. 30

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According to a fourth aspect of the present invention 1 there is provided a wireline wherein the wireline is 2 provided with an insulating coating. 3 4 The insulating coating is typically an outer coating 5 of the wireline. The wireline typically comprises a 6 slickline. 7 8 The insulating coating typically comprises at least 9 one enamel material. The enamel material typically 10 consists of one or more layers of coating whereby 11 each individual layer adds to the overall required 12 coating properties. Additionally, each layer of 13 enamel material preferably has the required bonding, 14 flexibility and stretch characteristics at least 15 equal to those of the wireline. 16 17 The enamel material can typically be applied to the 18 wireline by firstly applying a thin layer of 19 adhesive, such as nylon or other suitable primer. 20 Thereafter, one or more layers of an enamel material 21 such as polyester, polyamide, polyamide-imide, 22 polycarbonates, polysulfones, polyester imides, 23 polyether, ether ketone, polyurethane, nylon, epoxy, 24 equilibrating resin, or alkyd resin or theic 25 polyester, or a combination thereof, are preferably 26 applied. The enamel material is preferably 27 polyamide-imide. 28 29 According to a fifth aspect of the present invention 30 there is provided a communication system for use in a 31

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wellbore, the system comprising a transmitter coupled

- 2 to a wireline, and a receiver located remotely from
- 3 the transmitter, wherein the wireline is capable of
- 4 acting as an antenna for the transmitter.

5

6 The wireline is typically a slickline.

7

- 8 The transmitter is typically associated with,
- 9 provided on, or an integral part of a downhole tool
- or tool string, whereby the downhole tool or tool
- 11 string is typically suspended by the wireline.

12

- 13 The transmitter typically facilitates the
- transmission of data collected by the downhole tool
- or the like to the receiver. The transmission means
- typically comprises a transmitter. The receiver is
- 17 typically located at, or near, the surface.

18

- 19 Optionally, the communication system is arranged
- whereby it can facilitate two-way communication
- 21 between the downhole tool and the receiver. In this
- 22 embodiment, a transmitter and a receiver are
- 23 typically located downhole. Additionally, a
- transmitter and a receiver are also located at, or
- 25 near, the surface. The transmitter and receiver at
- the surface and/or downhole may be replaced by a
- 27 transceiver located downhole and at, or near, the
- 28 surface.

- The transmitter may be coupled to the wireline at any
- 31 point thereon, or may form a part thereof. The

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transmitter is typically coupled at or near a 1 downhole tool whereby the distance travelled by the 2 tool, the status of the tool or other parameters of 3 the tool, can be transmitted to the receiver. 4 Alternatively, the transmitter may form an integral 5 part of a downhole tool. 6 7 The wireline is preferably electrically insulated. 8 The wireline may be sheathed to facilitate electrical 9 Alternatively, the wireline may be insulation. 10 passed through a stuffing box or the like to 11 facilitate electrical insulation and/or isolation. 12 13 According to a sixth aspect of the present invention 14 there is provided apparatus for indicating the 15 configuration of a downhole tool or tool string, the 16 apparatus comprising at least one sensor capable of 17 sensing a change in the configuration of the downhole 18 tool or tool string and generating a signal 19 indicative thereof, and a transmission means 20 electrically coupled to the at least one sensor for 21 transmitting the signal to a receiver. 22 23 The downhole tool is preferably suspended in a 24 borehole using a wireline, and the wireline is 25 preferably capable of acting as an antenna for the 26 transmission means. 27 28 The transmitter typically facilitates the 29 transmission of data collected by the sensor to the 30 receiver. The transmission means typically comprises 31

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11 a transmitter. The receiver is typically located at, 1 2 or near, the surface. 3 Optionally, the communication system is arranged 4 whereby it can facilitate two-way communication 5 between the downhole tool and the receiver. In this 6 embodiment, a transmitter and a receiver are 7 typically located downhole. Additionally, a 8 9 transmitter and a receiver are also located at, or near, the surface. The transmitter and receiver at 10 the surface and/or downhole may be replaced by a 11 transceiver located downhole and at, or near, the 12 surface. 13 14 The sensor typically comprises an electric or 15 magnetic sensor which is coupled to the downhole tool 16 wherein a discontinuity of the electric or magnetic 17 connection triggers a signal, or a plurality of 18 19 signals. These signals can then be transmitted to the surface to indicate the status of the tool. 20 one embodiment, the sensor may be coupled between a 21 tool string and a downhole tool which is to be 22 deployed into a wellbore, wherein discontinuity of 23 the electric or magnetic connection indicates that 24 the tool has been deployed. Alternatively, the 25 sensor may be coupled to a distal end of the tool 26

27 string, and the downhole tool which is to be

retrieved from a wellbore, is provided with a similar

29 sensor, wherein continuity of the electric or

30 magnetic connection indicates that the tool has been

31 retrieved.

| 1 | |
|----|---|
| 2 | The sensor may also be coupled to part of a downhole |
| 3 | tool which changes status during operation of the |
| 4 | tool (ie a valve, sleeve or the like) wherein the |
| 5 | sensor indicates the status of the part of the |
| 6 | downhole tool by a change in continuity. |
| 7 | |
| 8 | The sensor may comprise a proximity sensor, magnetic |
| 9 | sensor or the like. |
| 10 | |
| 11 | The wireline is preferably electrically insulated. |
| 12 | The wireline may be sheathed to facilitate electrical |
| 13 | insulation. Alternatively, the wireline may be |
| 14 | passed through a stuffing box or the like to |
| 15 | facilitate electrical insulation and/or isolation. |
| 16 | |
| 17 | Embodiments of the present invention shall now be |
| 18 | described, by way of example only, with reference to |
| 19 | the accompanying drawings in which: |
| 20 | Fig. 1 is a part cross-section of a downhole |
| 21 | tool according to a third aspect of the present |
| 22 | invention; |
| 23 | Fig. 2 is a schematic diagram of a typical |
| 24 | wireline apparatus; |
| 25 | Fig. 3 is an enlarged view of part of the |
| 26 | wireline apparatus of Fig. 2; |
| 27 | Fig. 4 is a schematic diagram of a transmitter |
| 28 | which forms part of an electronic system for use |
| 29 | with the downhole tool of Fig. 1; and |
| 30 | Fig. 5 is a schematic diagram of a receiver |
| 31 | which forms part of an electronic system located |

at the surface for receiving signals from the 1 downhole tool of Fig. 1. 2 3 Referring to the drawings, Fig. 1 shows an embodiment 4 of part of a distance measuring apparatus, generally 5 designated 10. The apparatus 10 includes a slickline 6 12. Although reference will be made herein to use of 7 a slickline, it will be appreciated that other types 8 of wireline may be used, such as a braided line or 9 cable, coiled tubing or the like. Slickline 12 is 10 typically stored on a reel 14 which forms part of a 11 winching device 16 (Fig. 2), commonly known in the 12 art as a wireline winch unit. The winching device 16 13 is typically located at the surface. It should be 14 noted that "surface" in this context is to be 15 understood as being either atmospheric above ground 16 or sea level, or aquatic above a seabed. 17 18 The slickline 12 is introduced into a cased wellbore 19 (not shown) via a plurality of sheaves or guide 20 rollers, as illustrated in Fig. 2. The sheaves or 21 quide rollers divert the slickline 12 into a 22 substantially vertical orientation. The slickline 12 23 passes through a vertically-orientated superstructure 24 25 tube 18 which has an internal open-ended bore, the tube 18 being positioned above a wellhead, generally 26 designated 20. 27 28 Referring to Fig. 3, there is shown in more detail a 29 part of the slickline apparatus of Fig. 2. Located 30

at an upper end of the tube 18 is a sheave wheel 22

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which guides the slickline 12 from a substantially 1 upward direction through 180° to a substantially 2 downward direction. The slickline 12 then passes 3 through a stuffing box, generally designated 24 in 4 Fig. 3, which typically includes an internal blow-out 5 preventer (BOP) 26. 6 7 The slickline 12 enters the tube 18 and continues 8 downward therethrough and into a main BOP 28 and the 9 wellhead 20. 10 11 The slickline 12 is coupled at a lower end thereof to 12 a part of a downhole tool commonly known as a rope-13 socket 30 (Fig. 1). The main function of a rope-14 socket 30 is to provide a mechanical linkage between 15 the slickline 12 and the tool or tool string. 16 mechanical linkage may be any one of a plurality of 17 different forms, but is typically a self-tightening 18 In the embodiment shown in Fig. 1, the rope-19 socket 30 includes a wedge or wire retaining cone 34 20 which engages in a correspondingly tapered retaining 21 22 sleeve 36. 23 The rope-socket 30 is also provided with a sealing 24 means which seals around the slickline 12 to provide 25 a seal between the rope-socket 30 and the well 26 environment around the slickline 12. The sealing 27 means typically comprises a seal or gasket 44 which 28 isolates and insulates the interior of the rope-29 socket 30 from the well environment. 30

In the embodiment shown in Fig. 1, the rope-socket 30 1 also provides an electrical coupling between the 2 slickline 12 which is capable of acting as a 3 transmitter/receiver radio frequency (RF) antenna and 4 a downhole tool 32. The tool 32 typically comprises 5 an upper sub 38 which is coupled (typically by 6 threaded connection) to an intermediate sub 40, which 7 is in turn coupled (typically by threaded connection) 8 to a lower sub 42. 9 10 The upper sub 38 is provided with a screw thread 38t, 11 typically in the form of a pin, which engages with a 12 corresponding internal screw thread 30t, typically in 13 the form of a box, on the rope-socket 30. 14 (threaded) connections 30t, 38t allow the rope-socket 15 30 and tool 32 to be (mechanically) coupled together. 16 17 Additionally, the rope-socket 30 is provided with 18 coupling means which electrically couples a metal or 19 otherwise electrically conductive portion of the 20 slickline 12 and a transmitter 46 (a transceiver 21 typically being used to facilitate two-way 22 communication) of the tool 32. The coupling means 23 typically comprises an electrical terminal 48 which 24 is electrically isolated from the body of the rope-25 socket 30 using an insulating sleeve 50. 26 27 The upper sub 38 of the tool 32 is provided with an 28 electrical pin or contact plunger 52 which engages 29 with the electrical terminal 48 within the rope-30 socket 30. The contact plunger 52 is typically 31

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spring-loaded using spring 54 so that it can move 1 longitudinally (with respect to a longitudinal axis 2 of the tool 32) to facilitate coupling of the rope-3 socket 30 and the tool 32. A lower end of the 4 plunger 52 is in contact with a main contactor 56 5 which is electrically coupled to the transmitter 46. 6 This facilitates coupling of signals generated by the 7 transmitter 46 through the plunger 52 and the 8 terminal 48 to the slickline 12, the slickline 12 9 acting as an antenna for transmitting and/or 10 receiving signals, as will be described. 11 12 The tool 32 is also provided with an array of field 13 sensors 58 which are used to detect differences in 14 the magnetic flux at the junctions of, or collars 15 between, successive casing sections which are used to 16 case the wellbore, whereby the location of the tool 17 32 within the wellbore can be calculated, as will be 18 19 described. 20 The tool 32 is preferably powered by a (local) direct 21 current (DC) power source, typically comprising one 22 or more batteries 60. The batteries 60 provide a 23 local electrical power supply for the tool 32. 24 Conventionally, downhole tools are powered using a 25 central conductor of a braided line to transmit 26 electrical power to the tool from the surface. 27 However, there are substantial losses using this 28 method, particularly where the tool is located some 29 distance down the wellbore. In addition, the central 30 conductor of the braided line is typically relatively 31

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small in diameter and thus high voltage drops can be 1 induced. Use of a local power supply (ie the 2 batteries 60) obviates the need for an electrical 3 4 power connection to the surface. 5 The tool 32 may include a pressure sensor 62 which is 6 electrically coupled to the transmitter 46 and when 7 8 present can be used to measure the pressure external to the tool 32. 9 10 Referring now to Fig. 4, there is shown a schematic 11 diagram of a transmitter 46 which forms a part of an 12 13 electronic system located within the tool 32. batteries 60 provide electrical power to the system 14 in general. On detection of a positive over-pressure 15 to atmospheric level, that is after introducing the 16 tool 32 into the tube 18 (Fig. 2) and opening of the 17 wellhead 20 to allow well pressure to equalise in the 18 tube 18, the pressure sensor 62 activates the 19 magnetic field sensors 58. 20 21 The magnetic field sensors 58 may be of the type 22 23 described in German Patent Application Number DE-A1-19711781.3 (Pepperl + Fuchs GmbH), for example, and 24 are typically mounted within a section of the tool 32 25 26 which is at least partially manufactured from a conventional non-ferrous material. This ensures high 27 sensitivity when detecting casing or collar joints. 28 29

30 German Patent Application Number DE-A1-19711781.3

describes use of the sensors 58 in conjunction with a 31

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remnance inducing magnet ring. The wellbore casing 1 sections described therein exhibit a weak magnetic 2 remnance due to the influence of the earth's magnetic 3 field, the difference in the magnetic flux and/or the 4 history of previous well service operations. 5 difference in the magnetic flux at the junctions 6 between the wellbore casing sections is 7 insufficiently weak or disorientated, it is 8 advantageous to re-magnetise the casing sections by 9 either running in a separate downhole tool provided 10 with one or more axially orientated magnets prior to 11 commencing the tool detection, or to incorporate one 12 or more such magnets into the tool 32, or the tool 13 string of which the tool 32 forms part. 14 15 The plurality of sensors 58 are orientated to 16 preferentially sense the locality and proximity of a 17 collar or casing joint which the tool 32 passes, by 18 detecting the variation or switch in magnetic flux at 19 the junctions or collars between successive casing 20 sections. It is preferred, but not essential, to 21 have the sensors 58 disposed on a common horizontal 22 plane within the tool 32. The latter, in combination 23 with the series connection of the sensors 58 maximise 24 the positive sensing of the collars or casing joints 25 as the tool 32 passes. 26 27 When a casing collar or joint is detected, power is 28 supplied to the transmitter 46. The transmitter 46 29 is located within the tool 32 and is electrically 30 coupled to the batteries 60, the pressure sensor 62 31

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19 and the magnetic field sensors 58 via suitable 1 electrical connections within the tool 32. 2 Alternatively, the transmitter 46 may be coupled 3 thereto via a system of insulated downhole tool 4 components which provide electrical connections 5 isolated from the well environment, the electrical 6 connections being suitable connectors between the 7 separate downhole sections which make up the complete 8 9 downhole tool string. 10 The transmitter 46 may be of a type supplied by RS 11 Components under catalogue number RS 740-449, which 12 is designed to operate in conjunction with a 418 MHz 13 FM transmitter module also supplied by RS Components 14 under catalogue number RS 740-297. However, it 15 should be noted that the transmitter specified above 16 is only an example of one possible transmitter, and 17 that there are many other possible transmitters and 18 19 frequencies which could be utilised in it's place. The components identified above should be tested for 20 conformity to the particular operational requirements 21 and criteria and for operation in wellbore 22 environments. 23 The transmitter 46 typically has the facility for 25 26 4), and data bit settings using either a DIL switch 27 68 (Fig. 4) or driven by external switches, relay 28 29

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address coding (using DIL switch settings 66 in Fig. transistors or CMOS logic via an auxiliary connector, designated 70 in Fig. 4). DIL switch 68 is used to 30 switch data channels (ie the four data channels 31

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relating to each one of the sensors 58) on and off, 1 typically using opto-electronic switches 69. Thus, 2 the signal from any one, some or all of the sensors 3 58 can be set to be transmitted. The output from the 4 5 DIL switch 66 is typically processed by an encoder convertor 67 which encodes the address coding (as set 6 by the DIL switch 66) into the transmission. 7 transmission can be initiated by external contact 8 closure and the provided link on the auxiliary 9 connector 70 (eq, coupling TXEN to ground). 10 11 It will be appreciated that with the above described 12 transmission method, the transmitter 46 is not 13 permanently activated and allows only a single 14 transmission upon external contact closure. 15 duration of the transmission may be altered by 16 changing the values of RT, CT and/or RT2 and CT2 17 respectively, but is typically in the order of 1 18 19 second duration (set by default). The period of transmission may be determined as follows :-20 2.2*RT*CT (which changes the interval between 21 transmission in seconds) and 0.7*RT2*CT2 (which 22 changes the duration of the transmissions in 23 24 seconds). 25 The transmitter 46 ground connection (ie from any 26 point on the ground connection 64) and RFout 27 connection 65 are electrically coupled to the rope-28 29 socket 30 using, for example, electrical connections within the tool 32 (or otherwise as described above) 30 and the plunger 52 and electrical terminal 48 31

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21.

provided on the tool 32 and rope-socket 30 1 respectively (Fig. 1). These connections are shown 2 schematically in Fig. 4, with the RFout connection 65 3 being coupled to the slickline 12 which acts as an 4 5 antenna. 6 As previously noted, the slickline 12 acts as an 7 antenna for this RF transmission and thus the 8 9 slickline antenna 12 carries and guides the transmission towards the surface. 10 transmission (ie the electromagnetic (modulated) 11 wave) contains encoded data which is radiated into 12 free-space or any other antenna surrounding medium at 13 or near the tube 18, for example. The precise 14 location of where the RF transmission is radiated 15 16 into free-space is not important, but it is typically at some point at the surface where the RF 17 transmission can be radiated over a larger area. 18 19 Located within the radiation range of the transmitter 20 antenna (ie the slickline 12), for example located at 21 22 the surface or within the tube 18, is a receiver 80, shown in Fig. 5. Fig. 5 is a schematic diagram of 23 the receiver 80 which forms a part of an electronic 24 system located at or near the surface. The receiver 25 80 may be, for example, of the type supplied by RS 26 Components under catalogue number RS 740-455, which 27 28 is designed to operate in conjunction with a 418 MHz FM receiver module 84 supplied by RS Components under 29 30 catalogue number RS 740-304. However, it should be noted that the receiver specified above is only an 31

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1 example of one possible receiver, and that there are

- 2 many other possible receivers which could be utilised
- 3 in it's place. It should also be noted that the
- 4 receiver 80 should be matched to the frequency of the
- 5 transmitter 46. The components identified above
- 6 should be tested for conformity to the particular
- 7 operational requirements and criteria and for
- 8 operation in wellbore environments.

9

10 The receiver 80 typically has the facility for

11 address coding (using suitable DIL switch settings on

switch 82) to match and pair with the address code of

the transmitter 46. The settings of the receiver

14 board jumpers JP1 and JP2 determine the output

configuration of the transmission from the tool 32.

Jumper JP2 is used to select whether the output is

17 high or low (ie the logic level) which selects

whether the output on the four channels out 0 to out

3 on an auxiliary connector 88) are either a logic

20 high or a logic low. Jumper JP1 is used to select

21 whether the output on the channels out 0 to out 3 are

latched (ie permanently high or low) or intermittent.

23

The receiver module 84 receives the signal from the

antenna 12 at an RFin connection 86. The signal is

then processed in the FM receiver module 84 and

output to a decoder 90. The decoder 90 decodes the

address coding from the transmission and thus the

29 receiver 80 is only activated when the address of the

30 transmitter 46 matches the address settings of the

31 DIL switch 82 (ie the address of the receiver 80).

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23 The output from the decoder 90 is then fed to a data 1 selector 92 which automatically activates one, some 2 or all of the output channels out 0 to out 3, 3 depending upon which of the four channels have been 4 activated by the settings of the DIL switch 68 on the 5 transmitter 46. The output of the selector 92 is 6 then fed to a seven stage darlington driver 94 which 7 is used to drive the outputs on the auxiliary 8 connector 88. The outputs of the auxiliary connector 9 88, in particular the outputs out 0 to out 3 are 10 typically coupled to a visual indicator (ie a light 11 emitting diode (LED)) which can be used to allow a 12 user to determine which of the sensors 58 detected a 13 collar or casing joint. Alternatively, or 14 additionally, the outputs of the auxiliary connector 15 88 may be coupled to a processing means (eq a 16 computer) located at or near the surface for further 17 processing of the data. 18 19 It should be noted that although the transmitter 46 20 is shown coupled to four sensors 58 (Fig. 4) and thus 21 22 has four channels, the transmitter 46 may be provided with more or less than four channels, depending upon 23 the number and grouping of sensors 58 within tool 32. 24 25 In use, the tool 32 is attached to the slickline 12 26 as described above and introduced into a cased 27 wellbore in a conventional manner. The casing can be 28

of any type, that is, for example, either
electrically conductive or semi-conductive
ferromagnetic casing, or electrically non-conductive

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or non-ferromagnetic casing. The casing string 1 typically comprises of a plurality of casing lengths 2 which are threadedly coupled together, thus making 3 joints (or collars) therebetween. 4 5 The tool 32 is lowered into the cased wellbore using 6 the slickline 12. The slickline 12 is typically 7 formed of a metal which has a high yield strength to 8 weight ratio and is capable of supporting the tool 32 9 (and any other tools which may form part of a 10 downhole tool string). It will be appreciated that 11 the slickline 12 should also be capable of 12 functioning as a monopole antenna. 13 14 The slickline 12 is preferably (but not essentially) 15 electrically insulated and/or isolated using a thin 16 outer coating of a flexible, non-conductive 17 insulating material. It is preferred that the 18 material should also be chemical, abrasion and 19 temperature resistant to endure the hazardous 20 downhole environments. The coating is typically an 21 22 enamel coating. 23 It should be noted that it may not be necessary to 24 provide an insulating coating on the slickline 12. 25 If a stuffing box or the like is used, the slickline 26 12 will be electrically isolated by the stuffing box. 27 However, this requires that the slickline 12 does not 28 come into contact with any part of the conductive 29 wellbore which may be difficult in deviated

(horizontal) wells or the like. It is thus preferred

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that the slickline 12 is coated with an insulating

- 2 coating to ensure good electrical isolation. It
- 3 should be noted that coating the slickline 12 with an

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- 4 enamel material also protects the metal wire (from
- 5 which the slickline 12 is made) against corrosion.
- 6 In addition, or alternatively, a corrosive chemical
- 7 sensitive material(s) may be applied as a coating or
- 8 part thereof on the slickline 12, and this would have
- 9 the advantage that the presence of corrosive
- 10 chemicals, such as H₂S or CO₂ or nitrates, in the
- well would be indicated to the operator when the
- 12 slickline 12 is removed from the well since the
- 13 corrosive chemical sensitive material will be
- 14 transformed; for example, the colour of the corrosive
- 15 chemical sensitive material may change. In addition,
- or alternatively, a stress/impact sensitive
- material(s) may be applied as a coating or part
- thereof on the slickline 12, and this would have the
- 19 advantage that mechanical damage to the slickline 12
- 20 in the well would be indicated to the operator when
- 21 the slickline 12 is removed from the well, since the
- 22 stress/impact sensitive material will be transferred;
- for example, the colour of the impact/stress
- 24 sensitive material may change.

- The enamel material may consist of one or more layers
- 27 of coating whereby each individual layer adds to the
- overall required coating properties. Additionally,
- 29 each layer of enamel material preferably has the
- 30 required bonding, flexibility and stretch
- 31 characteristics at least equal to those of the metal

slickline 12 or coiled tubing. The thickness of the 1 enamel material can vary depending upon the downhole 2 conditions encountered, but is generally in the order 3 of 10 to 100 microns. 4 5 The enamel material can typically be applied to the 6 slickline 12 by firstly applying a thin layer of 7 adhesive, such as nylon or other suitable primer. 8 Thereafter, one or more layers of an enamel material 9 such as polyester, polyamide, polyamide-imide, 10 polycarbonates, polysulfones, polyester imides, 11 polyether, ether ketone, polyurethane, nylon, epoxy, 12 equilibrating resin, or alkyd resin or theic 13 polyester, or a combination thereof. The enamel 14 material is preferably polyamide-imide. 15 16 The conventional method of measuring downhole tool 17 depth is to run the slickline 12 against the sheave 18 wheel 22. It should be noted that use of "depth" in 19 this context is understood as being the trajectory 20 length of the downhole tool, which may be different 21 from conventional depth if the wellbore is deviated, 22 for example. In order to calculate the distance of 23 travel of the slickline 12, a number of variable 24 factors must be known. It is a prerequisite that the 25 rotational direction of the sheave wheel 22, the 26 number of revolutions thereof, the diameter of the 27 sheave wheel 22 and, depending upon the type of 28 sheave wheel 22 (that is, whether a point-type 29 contact or arc for example), the diameter of the 30 slickline 12, must all be known before the distance 31

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the depth correction.

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of travel of the slickline 12 within the wellbore can 1 be calculated (and thus the depth of the tool). 2 3 However, with this conventional method for 4 calculating the distance of travel of the slickline 5 12, a number of factors render the calculation 6 inaccurate. The occurrence of wheel slippage, the 7 stretch of the slickline 12 (whether due to the 8 weight of the slickline 12 itself, or the weight of 9 the tool string to which it is attached), the effect 10 of friction and the well-contained fluid buoyancy all 11 contribute to decrease the accuracy of the 12 conventional tool depth measurement. 13 14 In order to improve the accuracy of this conventional 15 depth measurement, it is known to combine the 16 measured tensile load, the known stretch co-efficient 17 of the slickline 12, and the conventionally measured 18 tool depth as described above, to recalculate the 19 tool depth measurement on a continuous (ie real time) 20 basis using a processing means (eg a computer). 21 22 However, the accuracy of the aforementioned depth 23 measurement correction method relies on an 24 experimentally determined constant (ie the stretch 25 co-efficient of the slickline 12) and the surface 26 measurements of the weight of the slickline 12. 27 resulting correction does not include the significant 28 29 combined effect that well fluid temperature, tool buoyancy and well geometry have on the accuracy of 30

| _ | |
|----|---|
| 2 | When the tool 32 detects a casing collar or joint |
| 3 | during normal slickline operations at downhole tool |
| 4 | travelling speed, the tool 32 will process the |
| 5 | collected data at normal wireline operational speed |
| 6 | using a processing device and signal generator 71 |
| 7 | (Fig. 4) which forms part of the transmitter 46. The |
| 8 | processing device and signal generator 71 |
| 9 | communicates a signal (via a SAW oscillator 73 and |
| 10 | 418 MHz band-pass filter 75) indicative of the |
| 11 | location of the collar or joint to the slickline 12 |
| 12 | which acts as an antenna. At the surface, this |
| 13 | signal is received by the surface receiver 80 (Fig. |
| 14 | 5). The receiver 80 is coupled to the processing |
| 15 | means (eg a computer) located at the surface and the |
| 16 | signal from the tool 32 is used to calibrate the |
| 17 | conventional measured depth against the known |
| 18 | distance between the preceding collar or joint, or |
| 19 | other known location. This distance is typically |
| 20 | known from an existing record log of the individual |
| 21 | casing lengths. |
| 22 | |
| 23 | A number of arrays of magnetic field sensors 58 |
| 24 | positioned on axially spaced-apart horizontal planes |
| 25 | within the tool 32 (as shown in Fig. 1) can be used, |
| 26 | each of the sensor arrays having their own channel as |
| 27 | described above and being set at known (but not |
| 28 | necessarily equal) distances along the longitudinal |
| 29 | axis of the tool 32. This allows for increased |
| 30 | accuracy of the calibration due to the repeated |
| 31 | calibration against the detected collar or joint. It |

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should be noted that when using multiple arrays of 1 sensors 58, only a single transmitter 46 and receiver 2 80 need be used as each array 58 will have their own 3 individual channel which can be selected or 4 deselected as required. 5 6 However, if the communication system is being used 7 with other sensors within the tool, these other 8 sensors may be coupled to another transmitter and 9 receiver, the other transmitter and receiver 10 including a different address coding. This allows 11 multiple transmissions to multiple receivers 80 from 12 multiple transmitters 46 using only one slickline 12 13 as the antenna. 14 15 The signal from the tool 32 is, for the purpose of 16 the described tool depth measurement calibration, a 17 measure of a known trajectory length of the tool 32 18 in relation to a detected collar or casing joint end 19 length (casing-section length calibration). 20 dependent upon the configuration of tool 32 within 21 the downhole tool or string. Alternatively, the 22 signal is a measure of the trajectory length as 23 travelled by the tool 32 in relation to the detected 24 collar or casing joint as indicated by each separate 25 positive signal from the tool 32 (downhole tool 26 27 length calibration). For the casing section length calibration technique, the accuracy of the 28 calibration may depend upon the accuracy and 29 completeness of surveyed well details, that is the 30

length of the individual casing sections and the

configuration thereof. For the downhole tool length 1 calibration method, surveyed well details are not 2 3 necessary. 4 With the casing length calibration method 5 (hereinafter CLC), the trajectory length or tool 6 depth calibration, as performed by the processing 7 means at the surface, uses the received signal from 8 9 the tool 32 and references this signal against the conventionally obtained surface measured depth, 10 obtained as described above, and the details of the 11 well. That is, the individual casing length is used 12 to calculate a depth correction factor μ wherein 13 14 $\mu_{\rm CLC} = L_{\rm c}/(D_2 - D_1),$ 15 16 wherein 17 18 19 $L_c = casing length;$ D_1 = surface depth at the previous casing collar or 20 21 joint; D_2 = surface depth at the detected casing collar or 22 joint, where $D_2 > D_1$; and 23 24 μ_{CLC} = depth correction factor. 25 The depth correction factor μ_{CLC} is used by the 26 processing means to correct the conventionally 27 obtained depth over the next downhole tool trajectory 28 29 casing length.

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With the downhole tool length calibration method
 1
      (hereinafter TLC), the trajectory length or tool
 2
      depth calibration is performed by the processing
 3
      means located at the surface, for example.
 4
 5
      processing means uses the received signal from the
      tool 32 and references this signal against the
 6
      conventionally obtained surface measured depth to
 7
 8
      calculate a depth correction factor \mu. The
      correction factor \mu can be calculated as follows for
 9
      equidistant sensor spacing (ie constant distance
10
11
      between sensors)
12
                          \mu_{TLC} = L_u/(D_n - D_{n-1}),
13
14
      wherein
15
16
      L_{\rm u} = tool sensor distance constant (ie the uniform
17
      distance between the sensors);
18
      D_1 = surface depth at the first tool sensor;
19
      D_{n-1} = surface depth at the previous casing collar or
20
21
      joint;
      D_n = surface depth at the detected casing collar or
22
      joint, where D_n > D_{n-1} > D_1; and
23
      \mu_{\text{TLC}} = depth correction factor.
24
25
      The correction factor \mu can be calculated as follows
26
      for non-uniform sensor spacing (ie non-constant
27
      distance between sensors)
28
29
                          \mu_{TLC} = L_n/(D_n - D_{n-1}),
30
```

32

1 2 wherein 3 L_n = tool sensor distance spacing (ie the non-uniform 4 5 distant between the sensors); D_1 = surface depth at the first tool sensor; 6 D_{n-1} = surface depth at the previous casing collar or 7 joint; 8 9 D_n = surface depth at the detected casing collar or joint, where $D_n > D_{n-1} > D_1$; and 10 μ_{TLC} = depth correction factor. 11 12 The depth correction factor μ_{TLC} thus derived can be 13 used by the processing means to correct the 14 conventionally obtained depth over the next travelled 15 spacing between the sensors (either uniform or non-16 If the total tool distance (that is the uniform). 17 distance between the sensors provided in the tool 32) 18 is less than the individual casing length, the 19 derived multiple-calibrated correction factor μ_{TLC} may 20 be used to correct the conventionally obtained depth 21 22 related input over the next downhole tool trajectory 23 individual casing length. 24 It will be appreciated that the depth correction 25 described above need not be performed in real-time. 26 A running history file can be constructed using each 27 surface-received signal from the tool 32 and after 28 29 completion of a slickline run (downhole tool travel 30 from surface to a depth and return to surface), the

history file can be compared against a similar file

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derived from the conventional depth measurement 1 technique and the results analysed to interpret and 2 evaluate the downhole tool run objectives and 3 results. 4 5 It will be appreciated that the use of a slickline as 6 an antenna is not limited to facilitate an increase 7 in accuracy of tool depth measurements. For example, 8 the conventional method for detecting the status of a 9 downhole tool or tools (that is a tool which is 10 deigned to perform downhole functions such as setting 11 plugs or isolating sections of the wellbore to deploy 12 memory gauges) would be by a differential calculation 13 involving the experience of the slickline operator in 14 conjunction with correlated depth between distance 15 travelled by the slickline (calculated using the 16 conventional technique) and the location of a 17 "nipple" in conjunction with the previously recorded 18 "nipple" depth or tubing tally, or by other means 19 involving physical stresses in the slickline (for 20 example increased/decreased tension in the 21 slickline). A "nipple" is a receptacle in which the 22 downhole tool locates and latches into, or the 23 position in the tubing or casing string for the 24 deployment of the downhole tool to carry out its 25 function. 26 27 Once the downhole tool has been deployed or 28 retrieved, the slickline winch operator typically 29 sees a corresponding decrease or increase in the 30 weight of the tool string equivalent to the weight of 31

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the tool, which would be indicative of a successful 1 deployment or retrieval. 2 3 However, where the downhole tool is of a marginal 4 weight so as not to show a significant difference in 5 the weight of the tool string once it has been 6 deployed or retrieved, or when circumstances inside 7 the wellbore give a smaller indication than one of 8 those described above (for example an obstruction in 9 the tubing or such like), the status of the downhole 10 tool is derived by conjecture until a time when the 11 function of the tool can be operatively tested or the 12 tool string is returned to the surface. 13 14 As will be appreciated, these methods of ascertaining 15 16 the status of downhole tools are not accurate and rely on the experience of the slickline winch 17 operator, a careful tally of running and pulling 18 weights, and accurate weight indication and depth 19 correlation means. Even when these criteria have all 20 been met, there is no quarantee that the downhole 21 tool has been successfully deployed or retrieved 22 correctly and where downhole tools which rely on the 23 position of sliding sleeves are used, there is no 24 indication of the position thereof until further 25 tests have been carried out. 26 27 28 The present invention facilitates a means to actively identify when a downhole tool has been deployed or 29 retrieved etc by incorporating into the previously 30 described apparatus one or more sensors (eg a 31

proximity or electrically connecting/disconnecting 1 sensor) which activates the transmission of a signal 2 via the slickline antenna which is indicative of the 3 status of the tool (ie latched, unlatched, engaged, 4 disengaged etc). This would provide a more reliable 5 indication of the tool status in connection with the 6 previously described depth correlation which 7 substantially mitigates the possibility of human 8 error in identifying whether the downhole tool has 9 been correctly deployed or retrieved etc. 10 11 When a downhole tool has been deployed, retrieved or 12 otherwise, it is normally the case to use a 13 mechanical force in order to facilitate this 14 15 deployment, retrieval or otherwise in order to operate a mechanism incorporated in the downhole tool 16 in order to carry out the function of the tool. 17 example of this would be a running tool which is used 18 to deploy a downhole plug which typically relies on 19 20 the slickline operator to locate the tool in its downhole position using the conventional depth 21 measurement. Thereafter, either pulling sharply on 22 the slickline or rapidly slackening it induces a 23 hammering effect on the tool whereby a pin (or a 24 plurality thereof) are sheared to allow the tool to 25 engage in a locking assembly, thus disconnecting the 26 tool from the string, or a collar is pulled to 27 28 retract such an assembly in order to release the tool from the locking assembly thus connecting the tool to 29 the string. 30

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1 A signal from a proximity sensor or the like can be

- 2 propagated to the surface using the slickline as an
- antenna, the signal being received at the surface and
- 4 causing, for example, a second signal to be
- 5 transmitted from the surface to a relay provided on
- 6 the (downhole) tool to electrically or
- 7 electromechanically operate an automatic locking or
- 8 unlocking device. This would eliminate the
- 9 requirement for mechanical hammering to initiate the
- 10 functioning of the downhole tool.

11

- 12 Another application of the present invention would be
- during the deployment of downhole tools, a part or
- parts of the tool itself or the tool string can
- loosen or be disconnected from the tool or string.
- 16 This can then require several runs into the wellbore
- in order to recover the tool or part thereof. This
- 18 can be a very expensive process.

19

- 20 To overcome this, the tools within the tool string or
- 21 the parts of the tool themselves can be coupled
- 22 together either electrically or magnetically wherein
- 23 discontinuity of the electrical or magnetic
- 24 connection triggers a signal or a plurality of
- 25 signals which can be transmitted to the surface to
- indicate to the slickline operator that such an event
- 27 is about to occur.

- 29 Modifications and improvements may be made to the
- 30 foregoing without departing from the scope of the
- 31 present invention. For example, the foregoing

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description relates to the use of a slickline as an 1 antenna, but it will be appreciated that it is 2 equally possible to use a braided line or a mono-3 conducting slickline. Additionally, the pulsed 4 transmission to the surface could be replaced by a 5 continuous type transmission, or alternatively, may 6 be a pulsed or continuous two-way communication 7 between the surface and a tool, using suitable 8 transmitters and receivers (or transceivers) for such 9 communications. 10 11 12 Although the foregoing description relates to the use of a tool which detects the location and passage of 13 collars in a cased wellbore, it will be appreciated 14 15 that tools exist which are sensitive to non-collared 16 pipe joints. 17 18 Additionally, it will be appreciated that the communication system described herein enables the use 19 20 of a slickline in combination with downhole tools, such as flow meters, pressure, temperature, 21 gravitational, sonic and seismic sensors, downhole 22 cameras and/or optic/IR sensors which have hitherto 23 relied on electric (single- or multi-conductor) 24

braided slicklines for operation.

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1 CLAIMS: -

2

- A communication system for use in a wellbore, 1. 3
- the system comprising a transmitter coupled to a 4
- wireline, and a receiver located remotely from the 5
- transmitter, wherein the wireline is capable of 6
- acting as an antenna for the transmitter. 7

8

- An apparatus according to claim 1, wherein the 9
- wireline is a slickline. 10

11

- 12 An apparatus according to either of claims 1 or
- 2, wherein the transmitter is associated with, 13
- provided on, or an integral part of a downhole tool 14
- 15 or tool string.

16

- An apparatus according to claim 3, wherein the 17
- 18 downhole tool or tool string is suspended by the
- 19 wireline.

20

- An apparatus according to either of claims 3 or 21
- 4, wherein the transmitter transmits data collected 22
- or generated by the downhole tool or the like to the 23
- receiver. 24

25

- 6. An apparatus according to any preceding claim, 26
- 27 wherein the receiver is located at, or near, the
- surface of the wellbore. 28

- An apparatus according to any preceding claim, 30 7.
- wherein the transmitter is coupled to the wireline at 31

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or near a downhole tool whereby the distance

- 2 travelled by the tool, the status of the tool or
- other parameters of the tool, can be transmitted to
- 4 the receiver.

5

- 6 8. Apparatus according to any preceding claim,
- 7 wherein the wireline is electrically insulated.

8

- 9 9. Apparatus according to any preceding claim,
- wherein the wireline is sheathed to facilitate
- 11 electrical insulation.

12

- 13 10. A method of communication in a wellbore,
- 14 comprising providing a transmitter coupled to a
- wireline, paying an end of the wireline and the
- 16 transmitter into the wellbore, and providing a
- 17 receiver located remotely from the transmitter, such
- that the wireline acts as an antenna for the
- 19 transmitter.

20

- 21 11. A wireline for use in a wellbore, wherein the
- 22 wireline is provided with an insulating coating.

23

- 12. A wireline according to claim 11, wherein the
- insulating coating is an outer coating of the
- 26 wireline.

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- 28 13. A wireline according to either of claims 11 or
- 29 12, wherein the wireline comprises a slickline.

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1 14. A wireline according to any of claims 11 to 13,

- wherein the insulating coating comprises at least one
- 3 enamel material.

4

- 5 15. A distance measurement apparatus for measuring
- 6 the distance travelled by a wireline, the apparatus
- 7 comprising at least one sensor coupled to the
- 8 wireline wherein the sensor is capable of sensing
- 9 known locations in a wellbore.

10

- 11 16. Apparatus according to claim 15, wherein the
- 12 wireline is typically a slickline.

13

- 14 17. Apparatus according to either of claims 15 or
- 15 16, wherein the apparatus includes transmission means
- 16 for transmitting data collected by the at least one
- sensor to a receiver located remotely from the
- 18 apparatus.

19

- 20 18. Apparatus according to claim 17, wherein the
- 21 wireline is capable of acting as an antenna for the
- 22 transmission means.

23

- 19. Apparatus according to either of claims 17 or
- 25 18, wherein the sensor is coupled at or near a
- downhole tool whereby the distance travelled by the
- tool, and the location of the tool within the
- 28 wellbore, can be calculated.

- 30 20. Apparatus according to any of claims 17 to 19,
- 31 wherein the wireline is electrically insulated.

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1 21. A method of measuring the distance travelled by

- a wireline, the method comprising the steps of
- 3 coupling at least one sensor to the wireline, the at
- 4 least one sensor being capable of sensing known
- 5 locations in a wellbore; running the wireline into
- 6 the wellbore; calculating the depth of the at least
- 7 one sensor; generating a signal when the at least one
- 8 sensor passes said known locations; using the signal
- 9 to calculate a depth correction factor; and
- 10 correcting the calculated depth using the depth
- 11 correction factor.

12

- 13 22. A downhole tool comprising coupling means to
- 14 allow the tool to be attached to a wireline, at least
- one sensor capable of detecting known locations in a
- wellbore and generating a signal indicative thereof,
- and a transmission means capable of transmitting the
- 18 signal.

19

- 20 23. A downhole tool according to claim 20, wherein
- 21 the wireline acts as an antenna for the transmission
- 22 means.

23

- 24 24. A downhole tool according to either of claims 22
- 25 or 23, wherein the coupling means comprises a rope-
- 26 socket.

- 28 25. A downhole tool according to claim 24, wherein
- 29 the rope-socket is provided with signal coupling
- 30 means to couple the signal generated by the
- 31 transmission means to the wireline.

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2 26. A downhole tool according to any of claims 20 to

- 3 23, wherein the downhole tool is powered by a DC
- 4 power supply.

5

- 6 27. A method of tracking a member in a wellbore, the
- 7 method comprising providing a sensor on the member,
- 8 inserting the member and sensor into the wellbore,
- 9 obtaining information indicating the position of the
- sensor in the wellbore, and determining the distance
- 11 travelled by said member from said sensor
- 12 information.

13

- 14 28. Apparatus for indicating the configuration of a
- downhole tool or tool string, the apparatus
- 16 comprising at least one sensor capable of sensing a
- change in the configuration of the downhole tool or
- 18 tool string and generating a signal indicative
- 19 thereof, and a transmission means electrically
- 20 coupled to the at least one sensor for transmitting
- 21 the signal to a receiver.

22

- 23 29. Apparatus according to claim 28, wherein the
- downhole tool is preferably suspended in a borehole
- 25 using a wireline, and the wireline is capable of
- 26 acting as an antenna for the transmission means.

- 28 30. Apparatus according to either of claims 28 or
- 29 29, wherein the transmitter facilitates the
- 30 transmission of data collected by the sensor to the
- 31 receiver.

Apparatus according to any of claims 28 to 30, 1 wherein the transmission means comprises a 2 transmitter. 3 4 Apparatus according to any of claims 28 to 31, 5 6 wherein the receiver is located at, or near, the surface of the borehole. 7 8 Apparatus according to any of claims 26 to 30, 9 wherein the apparatus is arranged whereby it can 10 facilitate two-way communication between the downhole 11 tool and the receiver. 12 13 Apparatus according to any of claims 28 to 32, 14 15 wherein the sensor comprises an electric or magnetic sensor which is coupled to the downhole tool wherein 16 a discontinuity of the respective electric or 17 magnetic connection triggers at least one signal. 18

20 35. Apparatus according to any of claims 29 to 34, 21 wherein the wireline is electrically insulated.

22

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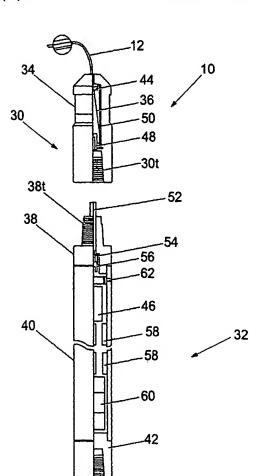
English

- (30) Priority Data: 9921554.3 14 September 1999 (14.09.1999) GE
- (71) Applicant (for all designated States except US): MA-CHINES (U.K.) LIMITED [GB/GB]; The Old School House, Udny Green, Ellon, Aberdeenshire AB41 7RS (GB).

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- (75) Inventors/Applicants (for US only): VAN DER ENDE, Andre, Martin [NL/GB]; The Old School House, Udny Green, Ellon, Aberdeenshire AB41 7RS (GB). COPE, John [GB/GB]; 47 Ninian Place, Portlethen, Aberdeen AB12 4QW (GB).
- (74) Agent: MURGITROYD & COMPANY; 373 Scotland Street, Glasgow G5 8QA (GB).
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[Continued on next page]

(54) Title: APPARATUS AND METHODS FOR MEASURING DEPTH



(57) Abstract: A communication system for use in a wellbore, a downhole tool, and a method includes a transmitter coupled to a wireline, and a receiver located remotely from the transmitter. The wireline is capable of acting as an antenna for the transmitter. The wireline is a slickline, and the transmitter may be associated with, provided on, or an integral part of a downhole tool or tool string. The transmitter typically transmits data collected or generated by the downhole tool or the like to the receiver, which is preferably located at, or near, the surface of the wellbore. The wireline is typically provided with an insulating coating. Also, a distance measurement apparatus and a method for measuring the distance travelled by a wireline includes at least one sensor coupled to the wireline, and the sensor is capable of sensing known locations in a wellbore.

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

(88) Date of publication of the international search report: 2 August 2001

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

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A. CLASSIFICATION OF SUBJECT MATTER IPC 7 E21B47/12 E21B47/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

 $\begin{array}{ccc} \text{Minimum documentation searched (classification system followed by classification symbols)} \\ \text{IPC 7} & \text{E21B} \end{array}$

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

| Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|
| US 4 001 774 A (DAWSON ET AL.) 4 January 1977 (1977-01-04) column 3, line 30 - line 64 | 1-13 |
| Cordinit 4, Title 19 Title 34 | 14,18, 20,23, 29,35 |
| US 4 814 548 A (TRAVERSINO ET AL.) 21 March 1989 (1989-03-21) column 1, line 44 - line 46 | 14 |
| US 3 209 323 A (GROSSMAN) 28 September 1965 (1965-09-28) column 5, line 18 - line 37 | 1 |
| | US 4 001 774 A (DAWSON ET AL.) 4 January 1977 (1977-01-04) column 3, line 30 - line 64 column 4, line 19 - line 34 US 4 814 548 A (TRAVERSINO ET AL.) 21 March 1989 (1989-03-21) column 1, line 44 - line 46 US 3 209 323 A (GROSSMAN) 28 September 1965 (1965-09-28) column 5, line 18 - line 37 |

| Further documents are listed in the continuation of box C. | Patent family members are listed in annex. |
|---|---|
| Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed | "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family |
| Date of the actual completion of the international search 28 February 2001 | Date of mailing of the international search report 0 6. 03. 2001 |
| Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016 | Rampelmann, K |

| C (Continu | ation) DOCUMENTS CONSIDERED TO BE RELEVANT | PC 8 00/03491 |
|------------|--|--|
| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
| Х | GB 936 461 A (TROSZT) 11 September 1963 (1963-09-11) | 15-17, 19,22, 24,25, 27,28, 30,32-34 |
| | page 3, line 27 - line 39 page 3, line 79 - line 91 page 4, line 49 - line 57 claim 1 | |
| Y | Claim 1 | 14,18, 20,23, 29,35 |
| X | US 3 267 365 A (BAKER) 16 August 1966 (1966-08-16) | 15-17, 19,22, 24,25, 27,28, 30,32,34 |
| | column 1, line 29 - line 35 column 4, line 34 -column 5, line 39 . | |
| X | US 3 185 997 A (CARLTON ET AL.) 25 May 1965 (1965-05-25) | 15,16, 21,22, 26-28,34 |
| | column 1, line 40 - line 42 column 2, line 32 - line 43 column 2, line 63 -column 3, line 42 | |
| X | US 4 044 470 A (DUFRENE) 30 August 1977 (1977-08-30) column 4, line 35 - line 68 | 22,24 |
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| Box I Ob | oservati ns where certain claims wer found unsearchable (Continuati n f it m 1 of first she t) |
|--------------|---|
| This Interna | tional Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons: |
| 1. Cla | aims Nos.: cause they relate to subject matter not required to be searched by this Authority, namely: |
| bed | aims Nos.: cause they relate to parts of the International Application that do not comply with the prescribed requirements to such extent that no meaningful International Search can be carried out, specifically: |
| | aims Nos.: cause they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a). |
| Box II Ob | oservations where unity of invention is lacking (Continuation of item 2 of first sheet) |
| This Interna | tional Searching Authority found multiple inventions in this international application, as follows: |
| Se | ee additional sheet |
| 1. X As | all required additional search fees were timely paid by the applicant, this International Search Report covers all archable claims. |
| | all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment any additional fee. |
| 3. As | only some of the required additional search fees were timely paid by the applicant, this International Search Report vers only those claims for which fees were paid, specifically claims Nos.: |
| 4. No res | required additional search fees were timely paid by the applicant. Consequently, this International Search Report is stricted to the invention first mentioned in the claims; it is covered by claims Nos.: |
| Remark on | Pr test The additional search fees were accompanied by the applicant's protest. X No protest accompanied the payment of additional search fees. |

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-14

Communication system

2. Claims: 15-35

Downhole depth measurement system

| | Inte | ormation on patent family memt | PCTAG | B 00/03491 |
|--|------|--------------------------------|-------------------------|------------------|
| Patent document cited in search report | | Publication date | Patent family member(s) | Publication date |
| US 4001774 | Α | 04-01-1977 | NONE | |
| US 4814548 | Α | 21-03-1989 | NONE | |
| US 3209323 | Α | 28-09-1965 | NONE | |
| GB 936461 | Α | | NONE | |
| US 3267365 | Α | 16-08-1966 | NONE | |
| US 3185997 | Α | 25-05-1965 | NONE | |

NONE

30-08-1977

US 4044470

REPLACED BY ART 34 AMDT

38

1 <u>CLAIMS</u>:-

2

- A communication system for use in a wellbore,
- 4 the system comprising a transmitter coupled to a
- 5 wireline, and a receiver located remotely from the
- 6 transmitter, wherein the wireline is capable of
- 7 acting as an antenna for the transmitter.

8

- 9 2. An apparatus according to claim 1, wherein the
- 10 wireline is a slickline.

11

- 12 3. An apparatus according to either of claims 1 or
- 13 2, wherein the transmitter is associated with,
- provided on, or an integral part of a downhole tool
- 15 or tool string.

16

- 17 4. An apparatus according to claim 3, wherein the
- 18 downhole tool or tool string is suspended by the
- 19 wireline.

20

- 21 5. An apparatus according to either of claims 3 or
- 4, wherein the transmitter transmits data collected
- or generated by the downhole tool or the like to the
- 24 receiver.

25

- 26 6. An apparatus according to any preceding claim,
- 27 wherein the receiver is located at, or near, the
- 28 surface of the wellbore.

- 7. An apparatus according to any preceding claim,
- 31 wherein the transmitter is coupled to the wireline at

39

or near a downhole tool whereby the distance 1 travelled by the tool, the status of the tool or 2 other parameters of the tool, can be transmitted to 3 the receiver. 4 5 Apparatus according to any preceding claim, 6 wherein the wireline is electrically insulated. 7 8 Apparatus according to any preceding claim, 9. 9 wherein the wireline is sheathed to facilitate 10 electrical insulation. 11 12 10. A method of communication in a wellbore, 13 comprising providing a transmitter coupled to a 14 wireline, paying an end of the wireline and the 15 16 transmitter into the wellbore, and providing a receiver located remotely from the transmitter, such 17 that the wireline acts as an antenna for the 18 19 transmitter. 20 A wireline for use in a wellbore, wherein the 21 wireline is provided with an insulating coating. 22 23 A wireline according to claim 11, wherein the 24 insulating coating is an outer coating of the 25 wireline. 26 27 A wireline according to either of claims 11 or 28 12, wherein the wireline comprises a slickline. 29

1 14. A wireline according to any of claims 11 to 13,

2 wherein the insulating coating comprises at least one

40

3 enamel material.

4

- 5 15. A distance measurement apparatus for measuring
- 6 the distance travelled by a wireline, the apparatus
- 7 comprising at least one sensor coupled to the
- 8 wireline wherein the sensor is capable of sensing
- 9 known locations in a wellbore.

10

- 11 16. Apparatus according to claim 15, wherein the
- 12 wireline is typically a slickline.

13

- 14 17. Apparatus according to either of claims 15 or
- 15 16, wherein the apparatus includes transmission means
- 16 for transmitting data collected by the at least one
- sensor to a receiver located remotely from the
- 18 apparatus.

19

- 20 18. Apparatus according to claim 17, wherein the
- 21 wireline is capable of acting as an antenna for the
- 22 transmission means.

23

- 24 19. Apparatus according to either of claims 17 or
- 25 18, wherein the sensor is coupled at or near a
- 26 downhole tool whereby the distance travelled by the
- tool, and the location of the tool within the
- 28 wellbore, can be calculated.

- 30 20. Apparatus according to any of claims 17 to 19,
- 31 wherein the wireline is electrically insulated.

41

1 21. A method of measuring the distance travelled by

- 2 a wireline, the method comprising the steps of
- 3 coupling at least one sensor to the wireline, the at
- 4 least one sensor being capable of sensing known
- 5 locations in a wellbore; running the wireline into
- 6 the wellbore; calculating the depth of the at least
- one sensor; generating a signal when the at least one
- 8 sensor passes said known locations; using the signal
- 9 to calculate a depth correction factor; and
- 10 correcting the calculated depth using the depth
- 11 correction factor.

12

- 13 22. A downhole tool comprising coupling means to
- 14 allow the tool to be attached to a wireline, at least
- one sensor capable of detecting known locations in a
- 16 wellbore and generating a signal indicative thereof,
- and a transmission means capable of transmitting the
- 18 signal.

19

- 20 23. A downhole tool according to claim 20, wherein
- 21 the wireline acts as an antenna for the transmission
- 22 means.

23

- 24 24. A downhole tool according to either of claims 22
- 25 or 23, wherein the coupling means comprises a rope-
- 26 socket.

- 28 25. A downhole tool according to claim 24, wherein
- 29 the rope-socket is provided with signal coupling
- 30 means to couple the signal generated by the
- 31 transmission means to the wireline.

42

1

2 26. A downhole tool according to any of claims 20 to

3 23, wherein the downhole tool is powered by a DC

4 power supply.

5

6 27. A method of tracking a member in a wellbore, the

7 method comprising providing a sensor on the member,

8 inserting the member and sensor into the wellbore,

9 obtaining information indicating the position of the

sensor in the wellbore, and determining the distance

11 travelled by said member from said sensor

12 information.

13

14 28. Apparatus for indicating the configuration of a

downhole tool or tool string, the apparatus

16 comprising at least one sensor capable of sensing a

change in the configuration of the downhole tool or

18 tool string and generating a signal indicative

19 thereof, and a transmission means electrically

20 coupled to the at least one sensor for transmitting

21 the signal to a receiver.

22

23 29. Apparatus according to claim 28, wherein the

24 downhole tool is preferably suspended in a borehole

25 using a wireline, and the wireline is capable of

26 acting as an antenna for the transmission means.

27

28 30. Apparatus according to either of claims 28 or

29 29, wherein the transmitter facilitates the

30 transmission of data collected by the sensor to the

31 receiver.

43

- 1 31. Apparatus according to any of claims 28 to 30,
- 2 wherein the transmission means comprises a

3 transmitter.

4

- 5 32. Apparatus according to any of claims 28 to 31,
- 6 wherein the receiver is located at, or near, the
- 7 surface of the borehole.

8

- 9 33. Apparatus according to any of claims 26 to 30,
- wherein the apparatus is arranged whereby it can
- 11 facilitate two-way communication between the downhole
- 12 tool and the receiver.

13

- 14 34. Apparatus according to any of claims 28 to 32,
- wherein the sensor comprises an electric or magnetic
- 16 sensor which is coupled to the downhole tool wherein
- 17 a discontinuity of the respective electric or
- 18 magnetic connection triggers at least one signal.

19

- 20 35. Apparatus according to any of claims 29 to 34,
- wherein the wireline is electrically insulated.

PATENT COOPERATION TREATY

REC'D 0 1 NOV 2001

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

| Applicant's or agent's file reference | FOR FURTHER ACTION | See Notification of Transmittal of International |
|--|---|--|
| P23959A/MGO/JDB | | Preliminary Examination Report (Form PCT/IPEA/416) |
| International application No. | International filing date (day/month | , |
| PCT/GB00/03491 | 12/09/2000 | 14/09/1999 |
| International Patent Classification (IPC) or nat E21B47/12 | ional classification and IPC | |
| Applicant MACHINES (U.K.) LIMITED et al. | | |
| This international preliminary examinand is transmitted to the applicant and is transmitted to the applicant and is transmitted. | nation report has been prepared coording to Article 36. | by this International Preliminary Examining Authority |
| 2. This REPORT consists of a total of | 11 sheets, including this cover s | heet. |
| been amended and are the basi | by ANNEXES, i.e. sheets of the is for this report and/or sheets co 7 of the Administrative Instructio | description, claims and/or drawings which have ontaining rectifications made before this Authority ons under the PCT). |
| These annexes consist of a total of 6 | S sheets. | |
| | | · . |
| This report contains indications relat I ☒ Basis of the report | ing to the following items: | |
| II Priority | • | |
| , | inion with regard to novelty inve | ntive step and industrial applicability |
| IV ⊠ Lack of unity of inventior | | intive step and industrial applicability |
| V 🛛 Reasoned statement und | | ovelty, inventive step or industrial applicability; |
| VI Certain documents cited | 1 | · |
| VII . Certain defects in the int | | |
| VIII 🗵 Certain observations on | the international application | |
| | | |
| Date of submission of the demand | Date of co | mpletion of this report |
| 12/04/2001 | 30.10.200 | 1 |
| Name and mailing address of the international preliminary examining authority: | Authorized | J officer |
| European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 6 Fax: +49 89 2399 - 4465 | | en, H No. +49 89 2399 7345 |

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/03491

| I. | Basis | of the | r port | |
|----|-------|--------|--------|--|
|----|-------|--------|--------|--|

| • | an | e receiving Office in | response to an invitation under of this report since they do not o | r Article 14 are | referred to in this i | report as "originally filed" |
|----|--------------|--|--|---------------------------------|---|--|
| | 1-3 | 37 | as originally filed | | | |
| | CI | aims, No.: | | | | |
| | 1-0 | 35 | as received on | 11/10/2001 | with letter of | 11/10/2001 |
| | Dr | awings, sheets: | | | | |
| | 1/5 | 5-5/5 | as originally filed | | | |
| | | | | | | |
| 2. | . Wii lan | th regard to the lang guage in which the i | juage, all the elements marked international application was file | above were a ed, unless othe | vailable or furnishe erwise indicated un | ed to this Authority in the der this item. |
| | The | ese elements were a | available or furnished to this Au | thority in the fo | ollowing language: | , which is: |
| | | the language of a t | translation furnished for the pur | poses of the in | nternational search | (under Rule 23.1(b)) |
| | | | blication of the international ap | | | (4,,40,,1,4,0,20,1,0)). |
| | | | translation furnished for the pur | | ` '' | examination (under Rule |
| 3. | Wit | h regard to any nuc rnational preliminar | leotide and/or amino acid sec y examination was carried out o | quence discloson the basis of | sed in the internation the sequence listing | onal application, the |
| | | contained in the int | ternational application in written | ı form. | | |
| | | | he international application in c | | able form. | |
| | | | ently to this Authority in written | | | |
| | | furnished subseque | ently to this Authority in comput | er readable fo | rm. | |
| | | The statement that the international ap | the subsequently furnished wri | itten sequence ished. | e listing does not go | beyond the disclosure in |
| | | The statement that listing has been fur | the information recorded in cornished. | mputer readab | ele form is identical | to the written sequence |
| 4. | The | amendments have | resulted in the cancellation of: | | | |
| | | the description, | pages: | | | |
| | | the claims, | Nos.: | | | |
| | | | | | | |

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/03491

| | | the drawings, | sheets: | | |
|----|---------------|--|------------------------|---------------------------|---|
| 5. | | This report has been a considered to go beyo | establish and the o | ned as if (disclosure | (some of) the amendments had not been made, since they have been as filed (Rule 70.2(c)): |
| | | (Any replacement she report.) | et conta | aining suc | ch amendments must be referred to under item 1 and annexed to this |
| 6. | Add | ditional observations, if | necessa | ıry: | |
| | | | | | · |
| IV | . Lac | ck of unity of inventior | 1 | | |
| 1. | In r | esponse to the invitation | n to rest | rict or pay | y additional fees the applicant has: |
| | | restricted the claims. | | | |
| | | paid additional fees. | | | |
| | | paid additional fees un | der prot | est. | |
| | | neither restricted nor p | aid addi | tional fee | es. |
| 2. | × | This Authority found th 68.1, not to invite the a | at the re | equiremer to restric | nt of unity of invention is not complied and chose, according to Rule or pay additional fees. |
| 3. | This | Authority considers that | at the re | quiremen | t of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is |
| | | complied with. | | | |
| | | not complied with for th | e follow | ing reasc | ons: |
| 4. | Con: exar | sequently, the following nination in establishing | parts of this rep | f the inter ort: | national application were the subject of international preliminary |
| | × | all parts. | | | |
| | | the parts relating to clai | ims Nos | • • | |
| V. | Rea: citat | soned statement unde ions and explanations | er Article s suppo | e 35(2) w rting suc | rith regard to novelty, inventive step or industrial applicability; |
| | | ement | | | |
| | Nove | elty (N) | Yes: No: | Claims Claims | 1-9, 14, 26, 33 10-13, 15-25, 27-32, 34-35 |
| | Inver | ntive step (IS) | Yes: | Claims | |

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/03491

Industrial applicability (IA)

Yes:

Claims 1-35

No:

Claims

2. Citations and explanations see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted: see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made: see separate sheet

Reference is made to the following documents:

D1: US-A-4 001 774

D2: US-A-3 267 365

D3: US-A-3 185 997

D4: US-A-3 209 323

Re Item IV

Lack of unity of invention

- Even though none of the independent claims seem to meet the requirements IV-1 of Article 33(2) or (3) PCT, this International Examining Authority confirms the founding of the International Searching Authority concerning the presence of two groups of inventions in the present application. Said two groups of inventions can be identified as follows:
 - 1. Claims 1-14: Communication system
 - 2. Claims 15-35: Downhole depth measurement system

The "special technical feature" (in the meaning of Rule 13.2 PCT) of the first group of inventions is that the wireline serves as a telemetry link between communications equipment located downhole and communications equipment located topsides. The problem solved by said feature is to provide a way of communication between said mutually remote locations.

The "special technical feature" " (in the meaning of Rule 13.2 PCT) of the second group of inventions is to provide depth information for equipment travelling up or down a well by referencing to known locations in said well. The problem solved is therefore how to know the actual travelled distance of a piece of equipment that has been placed inside a well.

The "special technical feature" of the two groups of inventions are therefore different and solve different problems so that no technical relationships can be seen among them. According to Rule 13.2 PCT, the application does therefore not meet the requirement of Rule 13.1 PCT.

EXAMINATION REPORT - SEPARATE SHEET

Re It m V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statem nt

D1, which is considered the closest prior art, discloses the subject-matter of V-1 claim 1 as follows (the references in parentheses applying to this document):

> A communication system for use in a wellbore (col. 1, I. 9-12), the system comprising a downhole tool (21), the downhole tool (21) comprising a transmitter (col. 3, I. 56), the downhole tool (21) being coupled to a wireline (40), wherein the downhole tool (21) and wireline (40) are adapted to be inserted into the wellbore (17), and a receiver (28) located remotely from the transmitter (see fig. 1), wherein the wireline (40) is capable of acting as an antenna for the transmitter (col. 3, I. 57-58).

The apparatus according to claim 1, therefore differs with respect to D1 in that the wireline is also capable of running the downhole tool into the wellbore.

The apparatus according to claim 1 is therefore new and the claim meets the novelty requirements of Article 33(2) PCT.

V-2 The distinguishing feature of claim 1 is thus related the problem of how to more efficiently deploy a device or downhole tool into a wellbore.

> In particular, in view of D4, fig. 1, said distinguishing feature of claim 1 does not involve an inventive step in the meaning of Article 33(3) PCT. It is considered obvious that the skilled man would adapt the teaching from D4 into D1 in order to solve the problem.

V-3 Furthermore, D1 discloses the subject-matter of the following claims:

Claim 2: see col. 4, I. 23-24

Claim 3: see fig. 1, item 21

Claim 4: see fig. 1, item 40 Claim 6: see fig. 1, item 28

Claim 7: see col. 3, I. 33-39

Claim 8: see col. 3, I. 58-59

Claim 9: see col. 4, l. 23-24

The subject-matter of said claims does therefore not involve an inventive step (Article 33(3) PCT).

With respect to independent claim 10, and in addition to what has already V-4 been said under section V-1, D1 in fig. 1 furthermore discloses that a wireline 40 including its ends with a transmitter 21 attached to the one of said ends, has in one way or another been payed into the borehole 17. See also col. 4, l. 27-34.

> Said claim does therefore not meet the novelty requirements of Article 33(2) PCT in that the claim is not new over D1.

- Also independent claim 11 as well as dependent claims 12 and 13 do not V-5 seem to contain novel subject-matter over D1 (see col. 4, I. 19-26). Said claims do therefore not meet the novelty requirements of Article 33(2) PCT).
- V-6 The subject-matter of dependent claim 14 is consider an obvious design alternative for the skilled man when solving the problem of insulation material selection. Said claim does therefore not involve an inventive step (Article 33(3) PCT).
- D2 discloses the subject-matter of claim 15 as follows (the references in V-7 parentheses applying to this document):

A distance measurement apparatus (fig. 1) for measuring the distance travelled by a wireline (17), the apparatus (fig. 1) comprising at least two sensors (fig. 6, item 64, 65) coupled to the wireline (17) wherein the sensors (64, 65) are capable of sensing known locations (15) in a wellbore (11).

The subject-matter of claim 15 is therefore not new contrary to the provisions of Article 33(2) PCT.

The applicants attention is drawn to the fact that even if D2 did not disclose a plurality of sensors, claim 15 would not be considered as involving an inventive step in the meaning of Article 33(3) PCT by just limiting the possible number of sensors to the system.

- Furthermore, D2 discloses the subject-matter of claim 16 as any line can be V-8 seen as a slick line. Claim 16 is therefore not new (Article 33(2) PCT). See also section VIII-3.
- V-9 Furthermore, D2 discloses the subject-matter of the following claims:

Claim 17: see fig. 1, item 56

Claim 18: see fig. 1, item 17

Claim 19: see col. 3, I. 48-52

Claim 20: see col. 2, I. 47

The subject-matter of said claims is therefore not new (Article 33(2) PCT).

Also the subject-matter of independent claim 21 and 22 is disclosed by D2. V-10 See in particular fig. 1 of D2. Refer also to sections V-5 above.

> The subject-matter of claims 21 and 22 is therefore not new contrary to the provisions of Article 33(2) PCT.

- V-11 Furthermore, D2 discloses the subject-matter of the following claims:
 - Claim 23: see fig. 1, item 17, where the cable 17 can be said to act as an antenna, i.e. the medium upon which the signal is transferred to the recorder 56.
 - Claim 24: see fig. 1, the socket is part of the arrangement referred to as 21.

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Claim 25: as the signal is clearly going from the sensor 50 to cable 17, the socket must include means to expedite the signal through the socket.

The subject-matter of said claims is therefore not new (Article 33(2) PCT).

- Claim 26 does not involve an inventive step (Article 33(3) PCT). See D3, fig. V-12 3, item 30.
- Independent method claim 27 relates effectively to the same subject-matter V-13 as independent claim 21 and does therefore also not meets the requirements of Article 33(2) PCT.
- V-14 As far as claim 28 can be understood, said claim relates effectively to the same subject-matter as independent claim 21 and does therefore also not meets the requirements of Article 33(2) PCT. See also section VIII-2.
- V-15 What has been said about claim 23 applies also to claim 29. The subjectmatter of said claims is therefore not new (Article 33(2) PCT).
- Furthermore, at least D2 discloses the subject-matter of the following claims: V-16

Claim 30: see col. 4, l. 48-52

Claim 31: see col 5, I. 30-32

Claim 32: see fig. 1, item 56

Claim 34: see col 4, I. 40-52

Claim 35: see: col. 2, I. 47

The subject-matter of said claims is therefore not new (Article 33(2) PCT).

With respect to claim 33, it is considered as normal practice, in the industry, V-17 to select between the features of having one-way or two-way communication between two stations, when designing a telemetry link. said claim does therefore not involve an inventive step (Article 33(3) PCT).

Re Item VII

Certain defects in the international application

- The independent claims are not in the two-part form in accordance with Rule VII-1 6.3(b) PCT, which in the present case would be appropriate, with those features known in combination from D1-D2 being placed, where appropriate, in the preamble (Rule 6.3(b)(i) PCT) and with the remaining features being included in the characterising part (Rule 6.3(b)(ii) PCT).
- VII-2 The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).
- VII-3 Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in D1-D4 is not mentioned in the description, nor are these documents identified therein.

Re Item VIII

Certain observations on the international application

- VIII-1 To satisfy the conciseness requirement or Article 6 PCT, the present set of claims should include only the minimum necessary number of independent claims in any one category. Said requirement is not satisfied by any of the independent claims, as in the present case, it is considered appropriate to use only one independent claim in any one category.
- VIII-2 Claim 28 in not clear (Article 6 PCT) in that it can not be determined if the "configuration of the downhole tool or tool string", as specified in the claim, refers to the location of the tool in the borehole or if it refers to the composition of the casing as such, alternatively to the tool string being run inside the casing.
- VIII-3 At least claims 2, 13 and 16 do not meet the requirements of Article 6 PCT in that the matter for which protection is sought is not clearly defined as the term "slickline" does not univocally imply any specific structural feature. The claim attempts therefore to define the subject-matter in terms of the result to



INTERNATIONAL PRELIMINARY

International application No. PCT/GB00/03491

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be achieved which merely amounts to a statement of the underlying problem. The technical features necessary for achieving this result should be added.

A. CLASSIFICATION OF SUBJECT MATTER IPC 7 E21B47/12 E21B47/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

 $\begin{tabular}{ll} \begin{tabular}{ll} Minimum documentation searched (classification system followed by classification symbols) \\ \begin{tabular}{ll} IPC 7 & E21B \end{tabular}$

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|------------|--|---------------------------|
| X | US 4 001 774 A (DAWSON ET AL.) 4 January 1977 (1977-01-04) column 3, line 30 - line 64 column 4, line 19 - line 34 | 1-13 |
| Υ | Column 4, Time 19 - Time 34 | 14,18, 20,23, 29,35 |
| Υ | US 4 814 548 A (TRAVERSINO ET AL.) 21 March 1989 (1989-03-21) column 1, line 44 - line 46 | 14 |
| A | US 3 209 323 A (GROSSMAN) 28 September 1965 (1965-09-28) column 5, line 18 - line 37 -/ | 1 |

| Special categories of cited documents: A* document defining the general state of the art which is not considered to be of particular relevance E* earlier document but published on or after the international | "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention |
|--|--|
| filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed | cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family |
| Date of the actual completion of the international search 28 February 2001 | Date of mailing of the international search report 0 6. 03. 2001 |
| Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016 | Authorized officer Rampelmann, K |

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Y Further documents are listed in the continuation of box C.

χ Patent family members are listed in annex.

INTERNATIONAL SEARCH REPORT

| C (Continu | ation) DOCUMENTS CONSIDERED TO BE RELEVANT | FC1/4B 00/03491 |
|------------|--|--|
| Category ° | | Relevant to claim No. |
| X | GB 936 461 A (TROSZT) 11 September 1963 (1963-09-11) | 15-17, 19,22, 24,25, 27,28, 30,32-34 |
| | page 3, line 27 - line 39 page 3, line 79 - line 91 page 4, line 49 - line 57 claim 1 | |
| Υ | Claim I | 14,18, 20,23, 29,35 |
| X | US 3 267 365 A (BAKER) 16 August 1966 (1966-08-16) | 15-17, 19,22, 24,25, 27,28, 30,32,34 |
| | column 1, line 29 - line 35 column 4, line 34 -column 5, line 39 | |
| X | US 3 185 997 A (CARLTON ET AL.) 25 May 1965 (1965-05-25) | 15,16, 21,22, 26-28,34 |
| | column 1, line 40 - line 42 column 2, line 32 - line 43 column 2, line 63 -column 3, line 42 | · |
| X | US 4 044 470 A (DUFRENE) 30 August 1977 (1977-08-30) column 4, line 35 - line 68 | 22,24 |
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INTERNATIONAL SEARCH REPORT



| Box I Observati ns where certain claims wer found unsearchable (Continuation f it m 1 of first sheet) |
|--|
| This International Search Report has not be in established in respect of certain claims under Article 17(2)(a) for the fillowing reasons: |
| Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely: . |
| Claims Nos.: because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically: |
| 3. Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a). |
| Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet) |
| This International Searching Authority found multiple inventions in this international application, as follows: |
| see additional sheet |
| As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims. |
| 2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee. |
| 3. As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.: |
| 4. No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: |
| Remark on Pr test The additional search fees were accompanied by the applicant's protest. X No protest accompanied the payment of additional search fees. |

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-14

Communication system

2. Claims: 15-35

Downhole depth measurement system

INTERNATIONAL SEARCH REPORT

information on patent family members

Int. al Application No PCT/GB 00/03491

| Patent document cited in search repor | t | Publication date | Patent family member(s) | Publication date |
|---------------------------------------|---|---------------------|-------------------------|------------------|
| US 4001774 | Α | 04-01-1977 | NONE | |
| US 4814548 | Α | 21-03-1989 | NONE | |
| US 3209323 | Α | 28-09-1965 | NONE | |
| GB 936461 | Α | | NONE | |
| US 3267365 | Α | 16-08-1966 | NONE | |
| US 3185997 | Α | 25-05-1965 | NONE | |
| US 4044470 | Α | 30-08-1977 | NONE | |